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Proceedings before the Metropolitan Board



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THE METROPOLITAN
BOARD OF HEALTH

Against

THE METROPOLITAN
GAS LIGHT
COMPANY.

LANE

MEDICAL



LIBRARY

LEVI COOPER LANE FUND

to you & to your associates, to read of them

I have now only one edition or set in pamphlet form & therefore have to send you the other unbound -

As I stated to you on Saturday we never intended to suppress experiments & improvements in surifying at our Works, on the contrary intended to resume them, as soon as we are left pressed for the supply than we are now

Mr Van Vorst will see Mr Bliss about the appointed order for Wednesday Jan'y 26th we had previously arranged for a Board meeting at about the same hour & I could not then attend them.

Yours Respectfully (P. A. Ollivier)
Leeds

Office of the Metropolitan Gas Light Co.

Corner of Broadway and 42d Street.

New-York, *Aug 24th 1868.*

Dr Eliza Harris

at the Board of Health

Dear Sir

It affords me pleasure to send you 3 copies of the testimonials taken by the Board of Health in 1867 for & aboard on the question of Purifying at this Company's Gas Works — I hope you & all your friends received some before, for at the time when we

to you & to your associates, to each of them

I have now only one edition or set in pamphlet form & therefore have to send you the others unbound -

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Yours Respectfully (Wm Ollivier)

Wm Ollivier



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Dr. Elisha H.

St. Cloud

Attest to be examined
/s/



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Dr. Elisha H.
St. Cloud

Arthur L. Leland
/s/

PROCEEDINGS

BEFORE

The Metropolitan Board of Health

ON THE APPLICATION OF

THE METROPOLITAN GAS LIGHT CO.

Large Library

MODIFICATION OF THE ORDER OF THE BOARD,

CONCERNING THE

MANUFACTURE OF GAS

AT THE FOOT OF WEST 42D STREET, NEW YORK.



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1869.

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List of Witnesses Examined.

SAMUEL P. PARHAM, p. 5, Aug. 10, 1868.

Prof. CHARLES F. CHANDLER, p. 26 and 1, Feb. 6,
1869.

Memorial of Gas Light Co.

Prof. BENJAMIN SILLIMAN, Jr., p. 35.

" HENRY WURTZ, p. 115.

OSCAR ZOLLIKOFFER, p. 160.

Jesse LISSENDEN, p. 169.

PETER CARTWRIGHT, p. 175.

ELISHA HARRIS, M. D., p. 183.

Counsel.

HOOPER C. VAN VORST,
Counsel for Met. Gas Light Co.

GEORGE BLISS, Jr., H. C. ALLEN and J. S. HASTINGS,
Counsel for Board of Health.

Referees.

D. B. HASBROUCK.

L. C. HAWLEY.

BEFORE THE
Metropolitan Board of Health. 1

IN THE MATTER
of
THE APPLICATION OF OSCAR ZOLLIKOFFER, President of the Metropolitan Gas Light Co., for the modification of Order No. 425, of the METROPOLITAN BOARD OF HEALTH, concerning the business of Manufacturing Gas, at the foot of West 42d Street, New York. 2

At a hearing before the undersigned, D. B. Hasbrouck, Referee, held at the office of the Metropolitan Board of Health, No. 301 Mott street, New York, on the 1st day of August, 1868, in pursuance of the order and notice of the Metropolitan Board of Health, a copy of which is herewith annexed. 3

By consent of both parties the hearing was adjourned to August 5, 1868, at 10 o'clock, A. M. No testimony was offered.

At the adjourned hearing, August 5, 1868, at same place, by consent of both parties a further adjournment

- 4 was had to August 10, 1868, at 11 o'clock, A. M. No testimony was offered.

At the adjourned hearing before the undersigned, D. B. Hasbrouck, Referee, held at the same place on the 10th of August, 1868.

Oscar Zollikoffer, Pres't Met. Gas Company, appeared in person and by H. C. Van Vorst, Counsel for the Company.

- 5 The Metropolitan Board of Health, by H. C. Allen, Esq., its Counsel.

Form No. 5.

Order No. 11.

Suspension of Order and Notice of Hearing, under the first clause of Section 14, of the Metropolitan Health Law, Chapter 74, of Laws of 1866.

6 OFFICE OF THE METROPOLITAN BOARD OF HEALTH, }
No. 301 Mott Street,
New York, July 29th, 1868. }

- 7 This Board having, on the 14th day of July, 1868, made an Order (being Order No. 425) relative to the business of manufacturing gas at the foot of West 42d St. N. Y., and having declared the same to be a public nuisance, and to the general effect that the business of manufacturing gas (conducted by the Metropolitan Gas Company) at foot of W. 42d St., N. Y., be discontinued, except it be conducted by a process of manufacture that will not allow any deleterious gases or odors detrimental to health to escape into the external air ; and the same having, on or about the 15th day of July, 1868, been served upon Oscar Zollikoffer, Pres't Metropolitan Gas Co., being the proper party, and said Oscar Zollikoffer having requested the opportunity to be heard before this Board, which said clause of said section authorizes, the execution of said order is hereby suspended until the further order of this Board.

And notice is hereby given to the said Oscar Zollikofer, who has requested an opportunity for a hearing, that he will be heard, and can present facts and proofs, as said law and the regulations of this Board provide, before this Board, at its office as above, on the 1st day of August, 1868, at 10 o'clock, A. M., on that day, or as soon thereafter as said hearing can be had. Said applicant must take notice of the adjournments of this Board, and of its rules and regulations, and of its final Order in this matter, and must be prepared to proceed in said matter, at said time and place, and at any subsequent meeting, as the business of said Board will allow; and all without further notice, beyond the service of a copy hereof. As witness the signature of

EMMONS CLARK,

Secretary of said Board of Health.

Adjourned to August 5th, at 10 A. M.

D. B. H.

Adjourned to August 10th, 1868, at 11 A. M.

Samuel P. Parham, called for the Metropolitan Gas Company, being duly sworn, testifies as follows :

By Mr. Van Vorst :

Q. Where do you reside?

A. 364 West 48th street.

Q. What is your business?

A. Gas engineer, of a practice of 26 years, and all branches connected therewith.

Q. How long have you been connected with the Metropolitan Gas Company?

A. Eight years, or nearly so, within a few months.

Q. In what capacity?

A. As assistant engineer in constructing works, and afterwards assistant engineer for the works of the Company.

Q. What are your duties as assistant engineer of the Company's works?

A. My special duties are charge of the distribution out-

12 side the works, and to assist the engineer when called upon inside, to make out drawings, alteration, or extension.

Q. With what Company were you connected before you connected yourself with the Metropolitan Gas Company?

A. Twenty years ago I was superintendent of the Trenton Gas Light Company; afterwards I was engineer, repairing works in different parts of the United States, and then, until eight years ago, in business for myself.

Q. Connected with the Philadelphia Gas Works?

A. No, sir.

13 Q. With what other gas works have you been connected?

A. The York, Pa., Gas Works, consulting engineer at Pottsville, consulting engineer at Frederick, Maryland, and at Columbia, South Carolina.

Q. Macon?

A. No, sir; I was the builder of the Trenton Water Works; that is outside the question, though.

Q. What had you to do with the process of manufacture of gas for the defendants?

A. I had more particularly the distribution, and to take the engineer's place when absent; at the same time I overlooked everything round the works for the Company's interest.

14 Q. What coal does the Metropolitan Gas Company use for the manufacture of gas?

A. They use different kinds of coal, but all of the best quality; they use the best coals in the city of New York or the United States; no better coals can be procured—Boghead, cannel coal, Ariston coal, Lothian, St. Hellen, Incehall, Leshmahago.

Q. Is this company particular about getting the best quality of coal, and that freest from injurious ingredients, out of which to make their gas?

A. No company in the United States has better coal than the Metropolitan; it buys the best that can be pur-

chased in the market ; the Scotch cannel ranks the 15
highest in the world, and we have it, and the bitumin-
ous holds the same rank.

Q. You import a good deal of coal ?

A. Yes, sir.

Q. Where are the company's works located ?

A. Forty-second street and North River.

Q. The gas is manufactured there ?

A. Yes, sir.

Q. Is it west of Eleventh avenue ?

A. Yes, sir.

16

Q. Can you state how the gas of the Metropolitan
Company is purified ?

A. Purified by what is called the dry lime process.

Q. Can you explain it ?

A. It is the oyster shell lime which is the best, be-
cause it is more like a powder ; it is moistened, damped
a little, and put into trays.

Q. You call them trays ?

A. Trays ; we put them on purifying boards, sieves. 17

Q. This lime is put in these purifying boxes ?

A. Yes, sir.

Q. Describe the process.

A. There are four purifiers, and the gas passes through
three of these boxes at one time, and passes through the
lime contained in these boxes ; we test the quality of
gas from time to time ; there is no set time to change
those boxes, but it is decided with a test paper ; when it
is shown that the gas is the slightest foul, a new purifier
is put on, and the old one is cleaned. 18

Q. How many boxes do you use ?

A. Four.

Q. Don't you use more than that ?

A. We have eight, that is two sets, four is a set.

Q. At certain seasons of the year you use them all ?

A. Yes, sir ; in the winter.

Q. Now will you state, if you please, what office the
lime performs in purifying the gas ; what it disengages
from the gas ?

19 A. It extracts the sulphuretted hydrogen gas, carbonic acid gas, whatever ammonia the water does not take out by the washers.

Q. Does the lime take out the ammonia?

A. Whatever portion comes through retains a good deal of it; we depend more upon the washers for the ammonia and upon the condensers.

Q. It takes out those matters?

A. From the gas; these are foreign matters we do not want; we want the illuminating matters.

20 Q. Do you know what becomes of them?

A. They are detained in the lime.

Q. They enter into combination with the lime?

A. Yes, sir.

Q. What does the lime become?

A. It becomes foul, as we say.

Q. You say it enters into combination with the lime?

A. In the washers it goes with the water and tar. The sulphuretted hydrogen and carbonic becomes here combined with the lime; these are the principal gases which are retained.

Q. You say they are taken up by the lime?

A. Yes, sir; and retained by the lime.

Q. Do any of them go into the air, and if so which?

A. When the lime is exposed, I presume they do—when the foul lime is exposed.

Q. What goes into the air?

A. The emanations from the lime—whatever has an affinity for the air has a tendency to pass off.

22 Q. What becomes of the lime?

A. The lime is thrown into the yard, and then sold as a fertilizer.

Q. State when, and how often the boxes are emptied?

A. We have no set time for the boxes?

Q. I mean for this lime?

A. Will say they work twenty-four hours during the winter, and during the summer, when our make is not

very great, run two or three days before the boxes are 23
changed ?

A. The lime is emptied—some coal contains more sulphur than others—the whole thing is a chemical counterbalance.

Q. Your effort is to get that coal which has least sulphur ?

A. Yes, sir ; it is the cheapest and best for the consumer.

Q. What becomes of the lime ?

A. The lime is taken out of the boxes and wheeled to 24
the yard, and there it remains, or from there it is conveyed upon vessels and carried to the country as a fertilizer.

Q. What agent is used in the purification of gas in the other works with which you have been connected ?

A. Lime ; dry lime ; I never used any other than dry lime.

Q. Have you had any experience in the use of any other agent except dry lime ?

A. No, sir ; I have tried experiments with iron filings and potash, but they were mere experiments. 25

Q. When did you perform these experiments ?

A. It was 20 years ago, in Trenton, New Jersey, in 1848.

Q. How did they succeed ?

A. They made gas very brilliant, sir, but very expensive. It was a mere laboratory experiment. Potash, iron filings, and sulphur. The sulphur need not have been there.

Q. Brilliant gas, but very expensive. 26

A. The process was very expensive ; it was too expensive for general use.

Q. Have you been at the New York Gas Works ?

A. Yes, sir.

Q. Lately.

A. Last Wednesday, sir, I was there looking at the process of purifying. I was accompanied by Mr. St. John, one of the patentees. He explained to me all, I presume ; I do not know that he kept anything back.

- 27 Q. What agent do they use there for purification ?
 A. Oxide of iron ; iron filings I saw there and charcoal, and I think he dampened it with ammoniacal liquor ; if there was anything else, he did not tell me of it.
 Q. You were there with the engineer ?
 A. With the patentee, Mr. St. John ?
 Q. Is their process of purification of gas patented ?
 A. Yes, sir ; it is in the composition ; it is not in the
- 28 method of purifying ; some compounds they have got there.
 Q. Have you ever witnessed any experiments for the purification of gas by that method except this one of the New York Company ?
 A. No, sir ; I have not ; but I have read a good deal of all kinds of processes in purifying gas ; a good many patents have been taken out for oxides—oxide of iron, oxide of zinc, oxide of manganese.
- 29 Q. Do you know what agent is used in the United States, in the large cities of the United States, for the purification of gas ?
 A. Generally dry lime ; Philadelphia uses it altogether, nothing else.
 Q. Do you know by whom the Philadelphia Gas Works are owned ?
 A. By the city of Philadelphia.
 Q. The Municipal Corporation of Philadelphia manufactures its own gas for the citizens ?
 A. Yes, sir.
- 30 Q. And in the process of the purification of the gas it uses dry lime ?
 A. Dry lime—yes, sir.
 Q. Do you know how it is in the city of Boston ?
 A. No, sir, not particularly ; I have not heard anything to the contrary of dry lime.
 Q. Do you know of any cities or any gas works where iron or the oxides of iron, or iron filings, or that process is resorted to for purification, except the New York Gas Works ?

A. None that I know of, or ever heard of. 31

Q. Which do you consider the best method of purification of gas, as far as your knowledge and experience is concerned ?

A. Dry lime process.

Q. Do you know of any evils attendant upon it, or any consequences injurious to health attendant upon that process of purification of gas which would not be attendant upon any other process ?

A. I do not know that this is unhealthy ; my family reside out of the city of New York, and I sleep off and on with a one foot brick wall between me and the purifying room, and I never was sick or experienced a headache, not the slightest indisposition ; in short, if there was an epidemic, I would remove my family to the works. In 1866, when the cholera was here, I slept that season in the works and never experienced the slightest indisposition ; if there was an epidemic, I would get my family as near the works as I could—either the yellow fever or cholera. There was but one person in Portsmouth, Va., that was taken with cholera, and he was taken from the works, and was brought back and recovered ; I have it from our engineer, who was in the neighborhood. 32

Q. Do you know of anything unhealthy about the Metropolitan Gas Works ?

A. I do not ; all our men are perfectly healthy ; I do not know of a case of sickness ; no later than Friday or Saturday there was two nurses with four children sent there by the physicians, with whooping-cough ; they were in the purification room inhaling the gas. 33

Q. Is it a usual occurrence for children to be sent there ?

A. Yes, sir ; I have known a great many.

Q. To inhale the gas as a medical agent ?

A. Yes, sir ; I have seen gentlemen bring their children there in carriages ; so it is not the lower class that comes there, but the higher class.

34 Q. What do you know about the health of the neighborhood of your gas works?

A. It is very healthy, sir, uncommonly, sir, round our immediate neighborhood.

Q. Do you know anything about any epidemics prevailing there among children or adults?

A. No, sir; there is a place opposite where there is a great many families; I do not know how many; I think there is but one death in a year; it is very seldom you see a funeral.

35 Q. Are there many children about your streets?

A. Yes, sir.

Q. It is a prolific neighborhood?

A. Yes, sir, quite so.

Q. You stated you observed the process of purification at the New York Gas Works?

A. Yes, sir.

36 Q. Will you state what you observed in regard to it, and what, if any, advantages or disadvantages there were attendant upon it, according to your observation and experience?

A. I could not see any.

Q. What?

37 A. Any disadvantages; but I think there must be a good deal in the gas, because I do not think it takes out all the *carbonic acid gas and sulphuretted hydrogen*; I do not think the iron takes all the carbonic acid gas; we want lime to detain carbonic acid gas; they were not using a particle of lime, and in many places where they do use the oxide of iron they must use lime; you cannot get along without lime, that is if you want pure gas.

Q. You cannot get along without lime in the purification of gas and have a pure gas?

A. I do not believe you can have a pure gas.

Q. The gas, you think, manufactured by the New York Gas Company is not as pure as the gas manufactured in your works?

A. I do not think it is as pure, and I do not think its

illuminating power is as strong; that is by eye observ- 38
ation, from looking at it, sir.

Q. What effect has it upon the health where gas of that character is burned, where those injurious elements of which you speak are not taken from it?

A. I should think injurious to health; if it was not injurious to health there would be no necessity for us to take it out, for it costs us something to do it.

Q. You take it out as a matter of healthfulness, this portion of the gas?

A. Yes, sir.

Q. And the lime process really does extract them, and if they were not taken out they would be evolved in the process of combustion? 39

A. Yes, sir; if we did not take it out there, the consumer would get it.

Q. Did you explain what became of the lime after the boxes were emptied?

A. It was taken out, thrown into barrels and taken into the yard, and from there we ship it in canal boats, and it is conveyed in different parts of the country as a fertilizer.

Q. And it is a good fertilizer?

A. Yes, sir; we use it ourselves for filling—mixing it with “breeze” or coke dust. Permit me to read a little paragraph. It is by Lewis Thompson, one of the best gas authorities in England. (Witness read from “The Chemistry of Gas Lighting,” London, as follows): at page 40
31, he says:

“Every one knows that the purifying agent first employed by Windsor was lime; and recent experiments, conducted with the most scrupulous care and by the most experienced manipulators, have shown, beyond all doubt or question, that nothing whatever is so well adapted for the complete purification of gas from its most pernicious impurities; and nothing tends so much to preserve its illuminating power, as the very article used and selected before all others by Windsor—that is to say, common lime. It would hence appear that our

41 progress in the art of purifying gas has been *nil*; for, although almost every chemical agent of a moderately cheap kind has found itself enlisted into the service by one patentee or another, yet, in the present day, those best acquainted with the purification of gas in a particular way tell us unanimously, that lime alone is the only substance which will effectually remove the chief impurities of coal gas, without so serious a destruction of illuminating power as to require the introduction of a new element in the calculation of the cost. That is to say, the employment of a portion of cannel coal by way of compensating for the loss which every other purifying agent but lime causes in the illuminating power of gas.

“That common lime used in a dry lime purifier is the most effectual, economical, and least hurtful agent to which impure gas can be subjected, no practical man can venture to deny; and next to this may be classed lime, used in a wet purifier, though this is much less effective, and very apt to leave carbonic acid in the gas. Of course this purification goes no further than to the acidulous compounds contained in the gas, such as carbonic acid and sulphureted hydrogen. But something may be learned nevertheless, from this peculiar fitness of lime, even in respect to the removal of the alkaline compounds. It would appear, that neither carbonate of lime, nor the hydrosulphate of lime possesses any affinity for those naphthas, or hydrocarbons, upon which the luminosity of gas depends. Hence, the lime when fully saturated, or, as the phrase is, when “foul,” contains nothing of the light-giving principles of gas, for these have passed on untouched. A very different result, however, takes place with the oxides, carbonates, and sulphates of the metals proper.

43 Q. What do you say about him as an authority?

A. He is a gas authority.

Q. How eminent an authority?

A. One of the most eminent men. Dr. Letheby, I think, is ahead of him.

Q. What other author have you?

A. Rev. Mr. Bowditch's Analysis—page 21—he 44
speaks of all the processes from the beginning.

Q. Which process does he favor ?

A. He seems to favor his own.

Q. What is that ?

A. Hot lime and clay purification. I do not know of
anybody using that at all.

Q. What does he say about the lime process—dry
lime ?

A. Page 21, speaking of the oxide, he says : " Al-
though this process of purification is a great point to 45
large gas companies, it has its drawback to consumers.
Because when it comes into use much carbonic acid is
left in the gas ; and secondly, because, when the foul
oxide is spread out to revivify, it casts off a quantity of
very offensive compounds, which seriously annoy those
who reside in the neighborhood of the works ; where the
foul oxide is exposed to revivify in the free air, the evo-
lution of sickening vapors emitted by foul oxide may be
carried through chimnies, and through fires, into the
atmosphere so as to be rendered harmless."

I have the report of the annual meeting of the British 46
Association of Gas Managers ; they have a number of
processes introduced ; there is one I should like to say
something about ; it is the fifth annual general meeting
of the General Association of Gas Managers, held in
London, June 2d, 3d and 4th, 1868 ; I read from the
Journal of Gas-Lighting, page 474, from the President's
Inaugural Address : " In the process of purification, but
little advance has been made. Experience, however, 47
serves to confirm Dr. Letheby, that the sulphur com-
pounds in gas may be considerably reduced by dry pu-
rifiers of large surface, through which the gas passes
slowly. This has been shown to be the case at the Great
Central Gas Works, where the quarterly average of sul-
phur has by that means been reduced from 30 grains to
less than 20 grains per hundred cubic feet." In speak-
ing of the different tests : " Mr. Ellison, the chief of
the Experimental Works of the Paris Gas Company,

48 observes that any portion of sulphur in gas that can be injurious to health or to property, is that portion which is eliminated in the form of sulphurous acid during ordinary combinations, and that a laboratory test by means not commonly adopted, which can extract a larger quantity of gas, is, or ought to be useless as a test of the purity of the gas to the public." There are a great many others, if you wish to have them; I have these papers for a number of years.

Q. The dry lime process has the effect to remove the
49 sulphur from the gas?

A. Yes, sir; sulphuretted hydrogen and carbonic acid.

Q. And is the best known agent that you know of to remove it?

A. Yes, sir.

Q. If not removed it remains with the gas, and is evolved with its combustion?

A. Yes, sir; it goes out somewhere.

Q. And makes the gas impure and injurious to
50 health?

A. Yes, sir; in 1866 the Great Central Gas Company begged to be permitted to use wet lime purifiers; that is, in the second rank of purifiers; Mr. Thompson states, the first is dry lime, and the second is the wet lime process; and the third the oxide metals—of zinc, iron or other metals.

At the thirty first half yearly ordinary meeting of the shareholders of the Great Central Gas Consumers' Com-
51 pany, held in London, October 26, 1866, the chairman said:

(Witness read as follows:)

"The sulphur question is one of our great difficulties. We have grappled with it in the most effectual manner we can. We have done everything in our power to reduce the quantity in the gas; we have gone to a large expense in picking out the pyrites from the coal, and

we have employed a most eminent chemist, Professor Redwood, in addition to our ordinary staff, to assist us in our endeavors to get rid of the cause of complaint, We also invited Dr. Letheby, though without success, to visit our works, and favor us with any suggestions in his power upon the subject. It is one of those obscure things which we cannot fathom. Sometimes we are below 20 grains; occasionally we are above that standard. Of course, in purchasing coal, our great object is to obtain that which contains the least sulphur, but it will occasionally happen that coal in the same pit, as the vein is worked out, is found to have a larger quantity of sulphur in it at one time than at another. We should have no difficulty whatever if we could use the wet lime process of purification. Some companies are so situated that they can do so, but if we were to attempt to do it at Bow Common, as we used to do, we should fall again into trouble with the local authorities. We have been brought up before the police magistrate for nuisance." "The use of wet lime is, therefore, prohibited to us. We are about to try some modification of the lime process. using lime in some form, and to a certain degree to enable us to come within the standard prescribed by Parliament, which I hope may be successful." (*The Journal of Gas Lighting, &c.*, Oct. 30, p. 790.)

Cross-examination, by Mr. Allen :

Q. To come back to the gas works of the Metropolitan Gas-Light Company : how long does this refuse lime remain on the premises ordinarily after it comes from the purifiers ?

A. A month or two—week—probably we take some in less than a week.

Q. Is it deposited in the yards in heaps ?

A. Yes, sir, there is a heap of it in the yard now.

Q. What is the condition of this refuse lime as to its temperature, when it comes out of the purifiers ?

A. It is warm.

56 Q. I mean at the time it is in the purifiers—is it hot or cold ?

A. Cold in the purifiers.

Q. On being exposed to the air does it become hot ?

A. Yes, sir ; it gets hot then ; it is the uniting of the air that makes it warm.

Q. Are there any odors escaping from this heap after it is exposed to the air ?

A. The greatest odors are in the removing from the purifier and taking it out.

Q. Answer my question, please ; are there, or are there not odors that escape into the air from this refuse lime after it is removed from the purifier ?

A. Yes, sir, a little.

57 Q. Do you know of what that odor consists—of what gases ?

A. Odor of sulphuretted hydrogen and ammoniacal odor.

Q. It is then the odor of gases that are absorbed in the purification.

A. Yes, sir.

Q. Do they undergo any chemical change by uniting with the oxygen of the air ?

A. I presume they do.

Q. Do you know what ?

A. No, sir ; I cannot say that I do, It throws off sulphuretted hydrogen and carbonic acid gas into the air ; and the lime after a while has no smell. The pile

58 there don't smell at all.

Q. You stated in your direct examination that the carbonic acid gas was taken out from the gas in these purifiers for the purpose of health ?

A. Yes, sir.

Q. Does carbonic acid gas in the gas diminish its illuminating power ?

A. It does.

Q. But you extract it because it is detrimental to health ?

A. It would be impure gas.

Q. To what extent would the amount of carbonic acid gas in the gas interfere with the illuminating power ? 59

A. I presume would lose a candle power or so. Some make it a great deal more than that ; and at the same time it would be impure gas.

Q. What is the amount of carbonic acid gas in a thousand feet of gas before it is purified.

A. I never measured ; we have no laboratory to measure it.

Q. Is there any perceptible difference in the amount of this odor which comes from the amount of refuse lime in the different degrees of temperature or humidity of the air ? 60

A. It is about the same to us at the works.

Q. The amount of odor is the same in wet weather as in dry ?

A. To us at the works ; I cannot answer anything beyond the works.

Q. Have you ever visited the Philadelphia Gas Works ?

A. Yes, sir ; many times.

Q. Did you perceive this same odor from this mass of lime in those works ? 61

A. Precisely the same—yes, sir.

Q. What knowledge have you of the health of the neighborhood in the vicinity of the Metropolitan Gas Works ?

A. It is said to be good.

Q. Have you any personal knowledge ?

A. I am there every day.

Q. Have you any personal knowledge ? 62

A. No, sir.

Q. You infer that the gas works are healthy, from the fact that physicians have sent children there ?

A. I only judge from myself.

Q. You mentioned the fact ?

A. Yes, sir ; physicians sent children there ; I was myself eighteen months inside the works ; I have slept inside the works, and never sick the slightest.

63 Q. Have you never heard of physicians giving strychnine to people sick ?

A. No, sir.

Q. Or calomel ?

A. Yes, sir ; I have taken it myself.

Q. Would you recommend that the whole community should be given a dose of calomel or strychnine ?

A. Might, if it would do them good.

Q. You are not an expert in medicine ?

64 A. No, sir.

Q. You have no knowledge of the effect of this gas upon the public health ?

A. No, sir.

Q. Will you state what, in the process of the New York Gas Works is patented ?

A. No, sir ; I never examined their claim ; it is in the composition ; they may use some little thing that others do not ; some patents contain saw dust ; they do not use saw-dust.

65 Q. Have you any knowledge of the illuminating power produced by the New York Gas Company ?

A. No, sir ; I have heard it was 13 or 14 ; I never examined it photometrically.

Q. Will you take that book—"The Chemistry of Gas Lighting"—and at page 32, and read the last clause at the bottom of the page, commencing "superior in activity ?" (Witness read as follows :)

66 A. "Superior in activity to the sulphate of lime, the muriate of that base next claims attention, and the mode of using this substance patented by Mr. Laming, seems to possess the greatest amount of advantages ; but whatever the plan, the theory and practice of the application of these lime salts are equally satisfactory ; the ammonia combined with carbonic acid is arrested by the lime salts employed, and a double decomposition, attended with the production of two new substances, neither of which have any affinity for the illuminating matters of the gas."

Q. Turn to page 36 (Chemistry of Gas-lighting.) and 67
read the first paragraph of the page, beginning "and
there is." (Witness read as follows:)

A. "And there is this very great advantage in favor
of the aforesaid arrangement of muriate of lime, oxide
of iron, and hydrate of lime, that it entirely obviates
all smell and nuisance from the Gas Works.

Q. Now, from the next paragraph, commenc'ng at
"foul lime."

(Witness read as follows:)

A. "Foul lime, as it is removed from the purifier, 68
consists of an admixture of several salts, some of which,
as the ferrocyanate, sulphocyanate, and hydrocyanate of
lime, are in such minute quantities as to require no no-
tice here; but there are others, such as the carbonate
and the hydrosulphate of lime, and the hydrosulphate of
ammonia, which are in considerable quantity and consti-
tute an important part of the total bulk. There is also
a quantity of hydrate of lime in an uncombined state,
and which may be said to be wasted. The analysis of 69
these principal compounds shows that the salts exist in
about the proportion which our estimate of the impuri-
ties in coal gas would indicate—that is to say, more than
half the mass consists of carbonate of lime, nearly one-
fourth of hydrosulphate of lime, about one-fifth is hy-
drate of lime unacted on, and the residue contains the
cyanogen, salts, and the silicious and other impurities of
the limestone, with a variable proportion of hydrosul-
phate of ammonia retained in the mass mechanically.
With such a mixture, it is not surprising that an offen-
sive odor is emitted on exposure to atmospheric air, for 70
in the first place, the hydrosulphate of ammonia must
pass into the air by a simple process of diffusion, whilst
the hydrosulphate of lime, being acted upon by the
carbonic acid of the atmosphere, will give rise to the
formation of carbonate of lime, and a copious evolution
of sulphuretted hydrogen gas. And it is in this latter
particular that the use of oxide of iron has its greatest
recommendation; for, as we have before stated, the affi-

71 nity of oxide of iron for sulphuretted hydrogen is greater than for carbonic acid, whereas with lime the contrary is true. Hence the sulphuret of iron, not being decomposed by the carbonic acid of the air, emits no odor, whilst the sulphuret of lime is readily decomposed, and thus produces an abominable nuisance."

Q. Now please read from page 37 the fourth paragraph, commencing, "But where."

(Witness read as follows):

72 A. "But where the necessity for avoiding nuisance is considerable, the spent lime should contain as little ammonia as possible, for the sulphuret of calcium alone decomposes very slowly by contact with atmospheric air, and has rather a tendency to absorb oxygen and generate hyposulphite of lime than to envelope sulphuretted hydrogen by combining with carbonic acid. When ammonia, however, is present, this rapidly ab-
73 sorbs carbonic acid; and the carbonate of ammonia, thus produced, instantly re-acts upon the moist sulphuret of calcium, whence result carbonate of lime and hydrosulphate of ammonia—the latter of which, by evolving its characteristic odor, gives rise to the well known offensive stench of gas lime refuse."

Q. Read from page 41, the last clause of the middle paragraph.

74 (Witness read as follows):

A. "Hence the oxides of manganese, iron, zinc, lead, copper and antimony, have been laid under the 'taboo' of the patent laws by various inventors, though at present the oxides of iron, lead and antimony, are the only ores in practical use in this country."

Q. Page 51, the last paragraph.

(Witness read as follows):

A. "In the April number of the *Journal of Gas Lighting*, for 1850, a communication will be found from a correspondent of the *Mining Journal*, which illustrates the above position. Having prepared a mixture of lime and sulphate of iron, so as to produce hydrated sesquioxide of iron, this was placed in a dry lime purifier, and the first trial was found to have purified only 1500 cubic feet of gas; after exposure to the air it purified 2400 cubic feet; on a second exposure to the air it purified 3050 cubic feet, and ultimately, upon another exposure, it reached as high as 4200 cubic feet, or very nearly three times the original quantity; and this result accords exactly with the daily experience of gas engineers upon this subject." 75

Q. In this work of Mr. Lewis Thompson's, in the paragraph you read on the 31st page—as I understand the drift of this work it is to determine which is the most economical method of manufacturing gas?

A. The least hurtful; on the same page it says that dry lime is the most effectual, economical and least hurtful agent to which impure gas can be subjected. 77

Q. I want to get at what he means by "hurtful;" hurtful to the public or hurtful to the gas?

A. Hurtful to the gas, I presume.

Q. Is this work (Chemistry of Gas Lighting) a sanitary work, or a practical work for the gas manufacturers?

A. It was written for the science of gas—for the gas engineer.

Q. Has no bearing whatever upon the result of gas making in a sanitary point of view? 78

A. I think not; it is to render impure gas pure gas; the object is to deliver as pure a gas to the consumer as possible; if it is an impure gas it is unhealthy, I presume.

Q. I understand you have never had any experience yourself in the oxide of iron process?

A. No further than the little experiments I spoke of; but not in a general way; for it is not used in this country.

79 *By Mr. Van Vorst :*

Q. How soon do the odors from the lime heap escape after being removed from the boxes ?

A. Almost as soon as the lids are removed.

Q. How soon does it terminate ?

A. Within three or four hours.

Q. Does that heap of lime emit any odors ?

A. No, sir ; not that I know of, sir.

80 Q. The heap of lime itself, after it is removed for two or three hours, emits no odors ?

A. No, sir ; the spent lime emits no odors.

Q. Your attention has been called as to whether you have any experience as to the health of the community ; I ask you what portion of your time you have spent in these particular gas-works for six or eight years past ?

A. I am there probably half my time.

Q. In the works ?

81 A. I am there four times a day, sir ; probably an hour each time.

Q. Have you any knowledge of any disease prevailing in that neighborhood among children or adults, more than any other part of the city ?

A. No, sir ; I have not heard of any.

Q. Or whether that neighborhood is a healthy or an unhealthy neighborhood ?

A. Never heard of its being unhealthy.

Q. Ever heard of any complaints from people in the neighborhood of it ?

82 A. No, sir ; I have heard them complain of smells, but smells of fat houses.

Q. Are there fat houses round there ?

A. Yes, sir ; there is a steamship that boils animals ; I have seen them piled up on the pier ; I think 38th street ; it is terrible ; sometimes makes me sick.

Q. Where is that ?

A. That on North river, just below me.

Q. Describe what kind of an establishment that is ?

A. I have never seen it only from our works; I have 83
seen animals go there.

Q. Dead animals that are carried there?

A. Yes, sir.

Q. Boiled up?

A. Yes, sir; or cut up in some way.

Q. Did you detect the odor from those works?

A. Yes, sir.

Q. I want to know what it is?

A. There are dead animals boiled there.

Q. Animals which have died a natural way, are sent 84
there and boiled?

A. Yes, sir; I have smelt it for eight years.

By Mr. Allen :

Q. Those are odors of decomposed animal matter?

A. Yes, sir.

By Mr. Van Vorst :

85

Q. Very disagreeable, and very offensive?

A. Yes, sir.

Q. Do you know of any other causes of the production
of disagreeable and offensive odors in that neighborhood?

A. No, sir; there is a sewer.

Q. How long has that establishment for boiling of
those dead animals been there?

A. It is eight years since I went there, and I have
smelt it there every year.

Q. Is it existing there?

86

A. Yes, sir.

By Mr. Allen :

Q. Has it ever made you sick?

A. Yes, sir.

By Mr. Van Vorst :

87 Q. Do you know of any useful purpose it is accomplishing ?

Q. No sir.

By Mr. Hasbrouck :

A. About how much lime is used ?

A. The charge to a purifier would be about two hundred and fifty bushels.

88 Q. Is it not practicable to immediately convey this lime when it is taken out of the purifier away to some place where it will be inoffensive ?

A. I think in a few hours after there is no smell.

By Mr. Van Vorst :

Q. How often do you open the boxes ?

A. Every two or three days; it is according to the gas passed through; in the winter time, when passing a large amount of gas, every day.

89 Q. Do you know anything about the arrangement made by the company for the removal of the lime ?

A. No, sir; the president has that arrangement.

Q. It is not allowed to remain there any longer than necessary ?

A. No, sir.

Prof. *Charles F. Chandler*, called for the Metropolitan Board of Health, being duly sworn, testifies as follows :

90 *By Mr. Allen :*

Q. What is your profession ?

A. A chemist.

Q. Are you connected with any public institution in this city ?

A. Yes, sir; I hold the chair of Analytical and Applied Chemistry of the School of Mines of Columbia College.

Q. And also chemist of the Metropolitan Board of Health ?

- A. Yes, sir. 91
- Q. Have you paid special attention to the chemistry of illuminating gas ?
- A. Yes, sir.
- Q. From what is illuminating gas prepared ?
- A. Bituminous coal.
- Q. What is the composition of bituminous coal ?
- A. Carbon and hydrogen with some sulphur and nitrogen, and earthy and silicious impurities which constitute the ash.
- Q. How is the gas prepared from the coal ? 92
- A. By exposing it to a high temperature in retorts of iron or clay.
- Q. What are the products of this ?
- A. Coke, tar, ammoniacal liquor and gas.
- Q. What becomes of these products ?
- A. The coke remains in the retort ; the tar and ammoniacal liquor accumulate in the hydraulic main, and in the condenser and scrubber ; the gas passes on to the purifiers. 93
- Q. What is the composition of the gas as it leaves the hydraulic main you speak of ?
- A. It consists chiefly of marsh gas, carbonic oxide, and hydrogen, which are the non-illuminating combustible constituents ; of olefiant gas and several other hydro carbon gases and vapors which are the illuminating constituents—sulphuretted hydrogen, carbonic acid, ammonia, cyanogen, sulpho-cyanogen, nitrogen ; (I believe those are the most important ones ;) bisulphide of carbon, aqueous vapors ; this last group of eight constituents constitute the useless or injurious impurities ; I did not mention the hydro-carbons individually ; there are a dozen or twenty which I group. 94
- Q. Have you ever visited the works of the Metropolitan Gas Company ?
- A. Yes.
- Q. What process do they use there for purifying the gas ?
- A. The dry lime process.

95 Q. What is the composition of the lime after it has acted upon the gas?

A. It consists essentially of sulphide of calcium, carbonate of lime, hydrate of lime; and contains small quantities of ammonia, cyanide of calcium, sulpho-cyanide of calcium.

Q. Is that all?

A. Except a little tarry matter; there may be minute traces of other things, but those are the essential constituents.

96 Q. What occurs when this spent or useless lime is exposed to the air?

A. The ammonia absorbs carbonic acid, forming carbonate of ammonia; the carbonate of ammonia decomposes the sulphide of calcium, forming sulphide of ammonia, which is evolved; carbonic acid decomposes sulphide of calcium, liberating sulphuretted hydrogen; oxygen is absorbed with the evolution of heat, and the formation of hyposulphite, sulphate and sulphate of lime; these are the more important reactions.

97 Q. What is the nature of this gas as to its offensiveness, when evolved in the air?

A. The sulphuretted hydrogen and sulphide of ammonia are the predominant constituents of the disagreeable odors evolved by the lime refuse.

Q. The fact is, that they produce a disagreeable odor?

A. They have a disagreeable odor?

Q. Is this disagreeable odor equally perceptible in all kinds of weather?

93 A. No; in dry, clear weather the odors rise rapidly in the air, particularly if the wind is in the proper direction, but in damp, heavy weather particularly with the wind favorable, the odor will diffuse itself throughout the neighborhood.

Q. Would this lime be equally offensive, if more lime were used for the same quantity of gas?

A. It would make a little difference, perhaps, but the odor is not due to over saturation; in fact, the refuse

contains fifteen or twenty per cent. of unchanged hydrate 99
of lime; consequently it is never over-saturated.

Q. Is it possible to prevent the escape of foul odors
from the dry lime process?

A. I think not.

Q. We come to another point: Is it necessary to em-
ploy the dry lime process for the purification of gas?

A. I think not; I know it is not.

Q. What is the wet lime process?

A. That is a process in which the lime is mixed with 100
a large quantity of water, to the consistency of cream,
and the gas obliged to bubble through it; the chemical
reactions are the same as in the dry lime process.

Q. Is that in general use?

A. No; I have seen it in use in some places, but I
believe it is generally abandoned; it is sometimes used
with the iron process, for the more complete removal of
carbonic acid, after the sulphur has been removed by
oxide of iron.

Q. What is Laming's process?

A. It consists in using a mixture of the hydrated ses- 101
quioxide of iron, sulphate of lime, hydrate of lime and
sawdust, or some other porous material; the mixture
consists of dry slacked lime and sawdust in equal quan-
tities, to which is added for every pound of lime one
pound of sulphate of iron (copperas), dissolved in water.
The mixture is exposed to the air for twenty-four hours,
to oxidize the protoxide of iron to the sesquioxide. It
then consists of hydrated sesquioxide of iron, sulphate of
lime, hydrate of lime, and sawdust.

In the place of copperas, double the weight of sesqui- 102
chloride of iron is sometimes used, when the mixture
consists of hydrated sesquioxide of iron, chloride of cal-
cium, hydrate of lime, sawdust.

Q. What are the disadvantages of Laming's process?

A. It is said to be somewhat more expensive in some
cities than the dry lime process; while in other places
it is said to be much cheaper.

Q. Has it any advantages?

103 A. It has been claimed by some that the gas suffers slightly in illuminating power, though even if this be true it could be easily remedied by the use of a larger proportion of cannel coal, or the use of small quantities of Albert or Boghead coal; it is stated, however, by others, that no such loss in illuminating power occurs; Unruh, in Magdeburg, where the process is employed, found that the illuminating power was not at all diminished, while the sulphuretted hydrogen was entirely, and the carbonic acid almost entirely removed, the process being much cheaper than dry lime; it has also been
104 stated that it fails to remove the carbonic acid completely; but should this difficulty occur, it can be easily remedied by the use of a little lime after the iron mixture; those are the answers as to the disadvantages.

Q. Has it any advantages?

A. The gas passes more readily through the mass—the mixture may be used over and over again—and when it has finally become useless for purifying gas, may be sold for the extraction of the sulphur it contains; but the most important advantage consists in the
105 entire suppression of the disagreeable smell which is evolved from the dry lime refuse.

Q. Will you describe the iron ore process?

A. In the iron ore process, brown hematite or bog iron ore, in coarse powder, is employed to absorb the sulphuretted hydrogen; this substance is an impure hydrated sesquioxide of iron, and has the same action on the sulphuretted hydrogen of the gas as has already
106 been mentioned in describing Laming's process; I am informed that at the new gas works in Berlin, a bog ore from Silesia is employed; it is dried, pulverized, sifted, and placed in the purifier either alone or mixed with sawdust; it is cheaper than Laming's mixture; it is regenerated slower at first, but more rapidly afterwards; and its action on the gas increases with use; at Hanover the iron ore of Lunenberg mixed with spent tan-bark is employed.

Q. Is this process in use in this country?

A. With slight modifications it is employed at the 107
New York Gas Company's Works, in East Twenty first
street.

Q. What are the modifications employed at the New
York Gas Works?

A. Iron ore of Staten Island is mixed with sufficient
quantity of iron turnings, filings or borings, to increase
the amount of iron to 80 per cent. ; the mixture is moist-
ened with ammonia water and exposed to the air, when
the metallic iron is rapidly oxidized ; when dry it is 108
mixed with about 5 per cent. of charcoal powder ; it is
then slightly moistened with water and placed in the
purifiers in a single layer two feet deep ; when the mix-
ture ceases to act upon the gas it is withdrawn and ex-
posed to the air, when it is rapidly regenerated, and may
be used over and over again ; the mixture now in use at
the works has been in use since April 21st.

Q. Is that process effective as a purifier ?

A. I cannot say of my own knowledge, but have
heard no complaints with regard to the quality of the 109
gas.

Q. Does the mixture evolve any disagreeable odor
after it has been used ?

A. I have noticed none ; I was there while the ma-
terial was being taken out of the purifiers and shoveled
over ; I detected no odor of sulphide of ammonia or sul-
phuretted hydrogen.

Q. Is it more expensive than dry lime process ?

A. I should think not ; the ore costs \$5 a ton, and is
used again and again ; while the lime is used but once ; 110
I was informed that the New York Company spent from
\$18,000 to \$19,000 a year for lime by the old process.

Q. Is this process used by the New York Company
patented ?

A. The combination of ore, iron turnings and charcoal
is covered by a patent. But the use of iron ore, or of
the oxide of iron, is not covered by a patent in this
country to the best of my knowledge. I would not say

111 decidedly, for I have not consulted the patent records to ascertain, but I think not.

Q. State generally from your information what processes are in use in Europe?

A. I have learned from numerous authorities that the iron process, either as Laming's process or as iron ore, is used in most of the large cities of Europe.

Q. To your knowledge have any of the commissioners sent to the Paris Exposition reported?

A. Professor J. Lawrence Smith, Professor of Chemistry in the Medical College at Louisville, and President of the Louisville Gas Company, made a report which I am informed was printed in the *American Gas-light Journal*, though I have not seen it. I have in my possession a letter from him.

112 Q. As a matter of information, state what he says?

A. He states that the oxide of iron process is generally used in all the cities of Europe. I do not like to say whether he says Europe or continent without glancing at it.

Q. Does this process of purifying gas by iron ore require any complicated apparatus?

A. The usual dry lime apparatus; of course some minor change, but no expensive change in the apparatus is necessary.

Q. Is there any essential difference in the coal employed in this country, and that employed in Europe which would make a process, which is successful there

113 unsuccessful here?

A. I think not; I have analysed numerous specimens of American coal, and do not remember that there was anything peculiar in their composition; that is, the coal used for gas making; we have a great deal of anthracite, but that is not involved in the question of gas making.

Q. Generally is it possible to obviate the present nuisance from gas works?

A. I think it is.

Q. How?

A. By introducing the iron process of purifying.

Q. How long would it take, in any particular gas works to make the changes necessary—take the Metropolitan Gas Works for instance—how long would it take these to make the necessary changes? 114

A. It is difficult to say how long; they would have to procure their oxides of iron; I should think two or three weeks.

Q. Would it interfere meantime with their manufacture?

A. Not at all; particularly as they have four idle purifiers; they could experiment on those without interfering at all with the four purifiers now employed for the dry lime process. 115

Q. Are sulphuretted hydrogen gas and the sulphide of ammonia injurious to health?

A. They are both poisonous gases.

Q. The question was, are they injurious to health?

A. They are.

Q. Did you ever know any one to be injured by them?

A. One of my assistants was rendered insensible by breathing sulphuretted hydrogen in the Laboratory at Union College. 116

Q. Are all persons equally susceptible to them?

A. No; they are not; my instructor in Berlin could not breathe sulphuretted hydrogen without getting the headache at once, while I have never suffered from it; numerous instances have occurred in which persons have been killed by sulphuretted hydrogen.

Q. Why is the sulphur removed from the gas at all?

A. Because it produces sulphurous acid, the burning of which vitiates the atmosphere; and it also acts upon metal, brass and copper, and would injure the brass fixtures. 117

Q. Why is the ammonia removed?

A. If it is left in the gas it produces nitrous acid, which would vitiate the atmosphere.

Q. Why is the carbonic acid removed?

A. Because it diminishes the illuminating power of the gas.

118 Q. Is there any sanitary objection to the carbonic acid gas being allowed to go through the main?

A. I should say not; for the reason that the combustion of the perfectly purified gas would produce many times as much carbonic acid as would commonly be contained in it; consequently the quantity in the gas is a very trifling matter.

Hearing adjourned to Thursday, August 13, 1868, at 11 o'clock A. M.

119

Memorial of the Gas Co.

*To the Honorable The Metropolitan
Board of Health:*

The Metropolitan Gas Light Company, of the City of New York, would respectfully represent that this company is the youngest of all the gas companies which supply the citizens of New York with gas; that its operations were commenced in the year 1863.

120 That its object from the beginning was to supply the consumers with pure gas and to conduct its manufactory in the best manner and according to the most approved methods science and experience could suggest.

That no complaint was ever made to this company that its method of purification of gas was offensive to the public, and that the first knowledge that the directors of this company had that your Board regarded its process of purification as injurious was the order of the 14th day of July, 1868.

121 The undersigned respectfully submits that the method adopted by this company for the purification of the gas delivered by it to the consumers is such as is in use in all the large cities of the United States, and is such as this company has had good reason to believe was the best which science and experience could suggest to effect the object to be secured—the delivery of the best gas to the consumer and manufacturer in a way to be the least offensive.

The dry lime process of purification used by this company is in general use by the gas manufacturers in the United States, as best adapted to free the gas from all impurities and offensive elements and substances. This company is aware that other methods of purification have been resorted to by some English companies, and on the continent of Europe, by the use of the oxide of iron for this purpose. But as at present advised such method has not fully succeeded to the satisfaction of either the manufacturer, consumer, or the public. It is urged by the objectors that the gas delivered by such process of purification is not freed from the offensive elements which the dry lime process removes, is impure and injurious to the health of the consumer, and it is represented to the undersigned that companies in Europe which had adopted it have abandoned it and gone back to the lime process. 122 123

This company has not yet had an opportunity to subject to a scientific and practical test the advantages of this method or others which may be suggested.

Unaware that any complaints were pending before your Board as to the operations of this company, and having no reason to believe that any just cause of complaint existed, it has heretofore used, as abovementioned, the lime process of purification. 124

Since the service on the company of the Order of the Board of Health, declaring this company's method of purification to be a nuisance, since testimony has been taken before D. B. Hasbrouck, Esq., at the rooms of the Board of Health, in regard to the advantages of the lead process of purification, and also of the iron process, which examination is still pending, unconcluded. 125

The undersigned most respectfully protesting against the adjudication of this honorable Board that their process of manufacture or purification of gas is a nuisance, still avow their willingness to try any method which science may suggest and experiment demonstrate to be a better one than that now in use.

This company is not wedded to and has no special in-

- 126 terest for the lime process of purification. If there is a better process it would gladly adopt it, so that it might manufacture gas in the least offensive manner, and deliver it to the consumer in the purest form.

This company submits that the mode of purification with the oxide of iron, or with iron in connection with other substances, is as yet an experiment only, and that such trial of its utility has not been had as to justify this company to abandon its present process and incur the hazard and expense of adopting it.

- 127 It is true, as the undersigned are informed, that one of the companies in New York has lately experimented on the iron process of purification, but the experiments have been so recent that they cannot as yet be called a success, and would not justify the undersigned in adopting it without a trial by themselves.

- This Company would respectfully suggest to your honorable Board, that all proceedings under the Code of the Board, including the further taking of testimony, be suspended until the Metropolitan Gas Light Company
128 shall have had time to subject the method of purification proposed and other methods to a practical test in its own works, and shall have had an opportunity to give the same a chemical examination by proper experts.

For this purpose the undersigned request a suspension of proceedings under the order, and the further taking of testimony until the first day of March next.

- This Company is at present engaged in considerable improvements in extending its works, and cannot in justice to the subject, its own interests and that of the consumers of its gas, before the time named sufficiently and properly at its works examine into and practically test
129 the new method proposed.

At the expiration of that time this Company will be prepared by experience to report to your honorable body the result of such scientific examination and trial.

Should this Company suspend operations in the manufacture and delivery of gas for a single day the community would be subject to great inconvenience; this

Company to large fines, and its chartered rights be put 130
in jeopardy.

It is submitted, that time and opportunity should be granted to this Company fairly to test by experiment the method of purification proposed, and should such trial and experiment prove that the method suggested is the best and freest from all objections in regard to all the parties and interests affected, including the sanitary and healthful consideration of the matter, this Company would gladly adopt it or any other measure, which judicious experiment would suggest. 131

The directors and corporators of this company are residents of the city of New York, and in common with all other citizens are interested in the health of its inhabitants.

This Company would do nothing to endanger the health of the city, and will do all in its power so to conduct its business in the meantime as to invoke no unfavorable action on the part of this Board, nor any complaint from any citizen.

All of which is respectfully submitted. 132

New York, August 17th, 1863.

On behalf of the Metropolitan Gas Light Company.

O. ZOLLIKOFFER,
Prest.

H. C. VAN VORST,
Of Counsel.

Before the Board of Health.

IN THE MATTER

of

The application of OSCAR ZOLLIKOFFER,
President of the Metropolitan Gas-
Light Company, for the modification
of the order No. 425, dated July
14th, 1868, of the Metropolitan
Board of Health, concerning the
business of Manufacturing Gas at
the foot of West 42nd Street.

1

The above proceedings adjourned from time to time,
until the 6th day of February, 1869.

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NEW YORK, February 6, 1869—1 P. M.

CONTINUATION OF THE HEARING BEFORE S. C. HAWLEY,
REFEREE.

Professor *Chas. F. Chandler* re-called, and cross-ex-
amined by Ex-Judge H. C. VAN VORST, testified as
follows:

Q. Have you given much attention to the chemistry
of illuminating gas?

- 3 A. I have been interested in the chemistry of gas to a greater or less extent for the last fourteen years.
 Q. Have you had occasion to visit many gas works?
 A. Quite a number.
 Q. In Europe?
 A. Some in Europe.
 Q. In this country?
 A. In this country.
 Q. Have you visited the Philadelphia gas works?
 A. I think I did visit them, but I have not a very
- 4 definite recollection; I saw all the sights in Philadelphia that interest chemists; I think I have visited the gas works there.
 Q. Can you state what process is in use in the United States for the purification of gas?
 A. The dry lime, or the wet lime process.
 Q. Which generally?
 A. The dry lime, I think.
 Q. How extensively does that prevail?
 A. Almost entirely.
- 5 Q. Are you acquainted with any exceptions to it?
 A. The New York Gas Company of this city, and two or three companies in New England.
 Q. Can you say where those gas companies in New England are located, that use any other process except the dry lime process?
 A. I should not like to say definitely.
 Q. You don't know?
 A. I have seen statements and letters from parties using the other process; but I have not interested myself sufficiently on that point to ascertain.
- 6 Q. Can you say then that any process for purification, except the dry lime process, is used of your own knowledge, by any other company except the New York Company, to which you have alluded?
 A. I have not seen it—no.
 Q. Nor can you mention by name any other company in any place that uses any other process, except the lime process?

A. Well, I think the Worcester and the Malden, are 7
using the iron process.

Q. Do you know that they do?

A. I have been so informed; I think those companies
were the ones.

Q. You think you have been informed?

A. I have been informed that companies were using
it, but my memory is a little uncertain as to which com-
panies they were.

Q. In the United States?

A. Yes, sir; but I am a little uncertain as to which. 8

Q. Except the New York Company?

A. Yes, sir.

Q. Do you know Professor J. Lawrence Smith, of
Louisville?

A. I do—yes, sir.

Q. You have spoken about him on your direct ex-
amination?

A. I have.

Q. Have you received some communication from 9
him?

A. Yes, sir.

Q. He is the President of the gas company at Louis-
ville?

A. Yes, sir.

Q. Do you know what process of purification is
adopted in his company?

A. I suppose the dry lime process.

Q. You suppose that this is in use in his company?

A. Yes, sir. 10

Q. Did you then mention all the elements of crude
gas? *

A. I think not. It was not my intention to mention
them all.

Q. What elements do you now state to be in the crude
gas which you did not then state?

A. There is such an indefinite number found in the

* Referring to Prof. Chandler's former testimony.

11 gas, and I have mentioned only those most important, that I should have to refer to my evidence to say which I did mention. I do not recall any important constituent that I should like to add to this list.

Q. There are none that you desire to add to it?

A. No.

Q. Did you regard carbolic acid, or phenol, as important?

A. I did not.

Q. Is it a constituent of crude gas?

12 A. There are minute traces of it in the crude gas.

Q. Have you visited the Manhattan works?

A. I have.

Q. Did you not then discover the presence of phenol—indications of it?

A. There was a slight odor which might be called that, and there might be a dozen other things—not with certainty.

Q. Where did you discover that?

A. I may say that there was a substance there that one
13 of my companions † pronounced to be phenol, though I did not feel certain about it. It was discovered about the spent lime which had been used to purify the air drawn from the main purifiers; also in the air which the Manhattan Company was allowing to pass into the atmosphere, in which we also discovered sulphuretted hydrogen.

Q. When you say in your testimony that the waste lime contains but small quantities of ammonia, do you include that contained in sulphide of ammonium or only
14 free ammonia?

A. I include ammonia in all forms.

Q. Is there not such an excess of ammonia in all cases that all the ammonia must be in the form of sulphide of ammonium?

Witness.—Do you mean in the gas or refuse lime?

Counsel.—Refuse lime.

- A. No ; I think not. 15
- Q. Why not ?
- A. Because there was an excess of lime there.
- Q. Is there much nephthaline in the waste lime ;
- A. There is some nephthaline.
- Q. Not much ?
- A. No, I should say not much.
- Q. Have you visited the Manhattan works since your direct examination ?
- A. Yes, sir.
- Q. Have or have not your views of the constitution of waste lime been modified by your observations during your visit to the Manhattan works—waste lime as spoken of in your testimony ? Your testimony was given with regard to the character of waste lime after it had acted as an agent in the purification of gas. 16
- A. Then my views have not changed with regard to the character of waste lime in general.
- Q. Has it in any regard changed ?
- A. It has changed somewhat in regard to the waste lime of the Manhattan Gas Company. 17
- Q. How so ; in what regard has it changed ?
- A. I don't consider the waste lime of the Manhattan Gas Company nearly as offensive or as liable to produce a nuisance as that of companies not employing the process used there.
- Q. What do you understand by the term nuisance ; you use the word ?
- A. Something so disagreeable to the senses or the sense of smell, in this case, as to cause complaint. 18
- Q. Can you move in any direction in the city without incurring something which is disagreeable to the sense of smell ?
- A. Yes, sir ; I walk up Fifth Avenue frequently without smelling any disagreeable smell.
- Q. Is that the only exception you make ?
- A. No.
- Q. Generally ?

19 A. Nuisances are by no means rare, and they differ in degree.

Q. Generally speaking, now, with regard to moving in any direction, persons that have delicate olfactory nerves—can they go anywhere in the city without meeting something which is disagreeable to the sense of smell?

A. No, I should think not.

Q. In the order of nature and the economy of the management of cities, those odors are constantly being evolved?

20 A. Yes, sir; to a greater or less extent.

Q. From a variety of causes?

A. Yes, sir.

Q. Is there not, as yet, much obscurity in the minds of the chemists generally about the complete nature of the action of the lime—the complete composition of the waste and the effluvia therefrom?

A. I think the main principles are pretty well settled. There is a difference of opinion about the detail and the minor reactions that take place.

21 Q. Is there not much obscurity still?

A. There is, about the minor changes that take place.

Q. Do not these require yet considerable analysis and investigation to reduce our knowledge to precision for scientific purposes?

A. They do. For sanitary purposes they do not.

22 Q. Is it not reasonable, Doctor, even for sanitary purposes, to expect such investigation would develop important improvements in the use of the dry lime process by which its offensive features, of which you have spoken may be removed?

A. I have no wish to predict the success of the future investigations in that direction.

Q. Don't you think that there is anything about it that would warrant any such conclusion as that?

A. Only as far as the investigations are liable to result in improvement.

Q. Is there anything in the subject matter itself which would warrant such conclusion as that?

A. Conclusion to what effect?

23

Q. By which the offensive features of the dry lime process may be removed?

A. I have already alluded to the fact that a process is in use in New York, in which the offensiveness is to a great extent removed.

Q. That is the Manhattan Gas Company?

A. Yes, sir.

Q. Aside from that?

A. Aside from that I have no reason to have an opinion one way or another.

24

Q. In reply to the question as to what occurs when the spent lime is exposed—the lime that has performed the office of purifying the gas—you described three or four actions; which of these predominates?

A. These reactions succeed each other so that it is difficult to answer that question directly.

Q. Which predominates?

A. Ultimately the oxidation of the sulphide of calcium predominates.

25

Q. Does not the oxidizing action predominate, as shown by the heat evolved?

A. The heat evolved would not prove anything with regard to the comparative reactions which take place.

Q. Then you infer that the oxidating action predominates otherwise than is exhibited by the heat?

A. Yes, sir.

Q. It does predominate?

A. I infer that it predominates, from the fact, that the sulphide of calcium is the predominating substance susceptible of change.

26

Q. Does the atmosphere contain enough carbonic acid to give prominence to the other two actions you suppose?

A. It does.

Q. Would not the oxidating action occur with the sulphide of ammonium as well as with the sulphide of calcium, converting it into hyposulphite or sulphite of ammonia?

27 A. I would infer from my laboratory experience that sulphide of ammonium is revolved directly into the atmosphere without undergoing material change.

Q. And you speak from no other experience except that, in that connection?

A. Yes, sir.

Q. Except your laboratory experience?

A. Yes, sir.

Q. Is not sulphide of ammonium a very unstable, perishable and transient substance in the air?

28 A. While I have no doubt that ultimately it undergoes decomposition in the air, I know from years of experience that it remains intact long enough, for a considerable length of time, as shown by its persistent odor.

Q. Where was that experience obtained? In the laboratory?

A. In the laboratory.

Q. I am now speaking about the external air, outside of the laboratory?

A. I don't make any difference on that point.

29 Q. Is it any more perishable in the external air than it is in the laboratory?

A. No.

Q. Is it no more readily dissipated?

A. Distributed, of course.

Q. You were talking about decomposition, and not distribution. It is decomposed more readily in the external air?

A. It is not.

30 Q. But it is distributed more readily?

A. Undoubtedly, if the wind is blowing, it is distributed more readily than shut up in the room.

Q. But is not lost.

A. Do you mean by decomposition?

Q. In any way?

A. It is lost if it is carried off by the wind, of course.

Q. And that is the only way in which it can be destroyed?

A. I have already stated that it may undergo decomposition. 31

Q. How may it undergo decomposition?

A. I am not prepared to give the definite decomposition that might take place.

Q. Is it likely to undergo decomposition?

A. I should think it might be.

Q. How soon?

A. I can't say.

Q. How soon after being evolved?

A. I can't say how soon.

Q. Have you no idea?

A. No definite idea. 32

Q. Is chemistry unable to furnish any solution of the manner in which it is decomposed, or the time in which it may be decomposed in the external air?

A. Probably it is able to do so. I don't claim to carry all the facts of science in my head.

Q. I want only to know, as far as your experience goes, whether chemistry can determine that question—as far as you know?

A. I can only say that I have not studied up that particular point. 33

Q. Is not sulphuretted hydrogen quickly destroyed by the air?

A. Yes, sir, ultimately—I suppose so. Sulphuretted hydrogen would be oxidized by the air.

Q. You make substantially the same answer to that, that you do to sulphide of ammonium—that it becomes decomposed after a while?

A. Yes, sir, I suppose so.

Q. Within what time after its evolution?

A. That I can't say. 34

Q. Sulphide of ammonium being volatile, would it not be necessarily decomposed by contact with the large excess of caustic-lime left in the spent lime?

A. It may be partially decomposed, but I think it is not completely decomposed.

Q. To what extent?

A. I have no data to say—to decide:

35 Q. Would not ammonia be thus set free and the sulphite of calcium formed?

A. That reaction might occur to some extent.

Q. It is not a necessary consequence? You say it might.

A. It is not a necessary consequence, because the hydrate of lime in the spent lime is so protected that it is not capable of exerting the action which it would exert under other circumstances, as shown by the fact that it is impossible to change all the hydrate of lime in the purifiers.

Q. Is pure ammonia offensive?

A. Not in moderate quantities.

Q. In quantities which are given off from such spent
36 lime would it not be?

A. No.

Q. Is the ammonia from the stables offensive?

A. Pure ammonia from the stables is not offensive.

Q. Nor deleterious to health?

A. No.

Q. On the other hand is it not regarded, for certain complaints, as healthful?

A. I should not care to answer the question in regard to that—that is to say whether it is healthful or not. I should not like to say about that. I believe it is; I am not a physician.

Q. But you don't regard it as deleterious to health?

37 A. I shouldn't consider it so.

Q. You have spoken with some degree of favor in your direct testimony, of the kinds of oxide of iron methods, and especially of the Laming process?

A. Yes, sir.

Q. Do you believe that these methods are equal in purifying the gas from sulphur to the lime process?

A. Not having investigated that point myself, and finding a difference of opinion among authorities, I am not in a position to answer the question definitely.

Q. I should like to have your opinion on that subject as an expert.

A. It is my opinion that, while the lime process may

take out a little more sulphur than the oxide of iron 38
 process, that the difference in the effect of the two is
 not sufficient to counterbalance the other advantages of
 the iron process. There are several iron processes.

Q. In your opinion, then—I am going back to the
 question because you have brought in other matters
 which I have no objection to at all—I ask you, then,
 in your opinion, whether they are equal—these two
 processes, the lime and the iron—equal in purifying the
 gas from the sulphur?

A. I think there is a slight advantage in favor of the 39
 lime process.

Q. Does the iron method extract the sulphur which is
 in the form of bisulphide of carbon?

A. That question has never been determined by ex-
 periment, to my knowledge.

Q. You can't answer the question?

A. No; not to my knowledge.

Q. Does it take out phenol?

A. I should make the same answer to that question 40
 that I made to the other.

Q. Does the iron process take it out?

A. It does not.

Q. Do you mean that lime takes it out of the crude
 gas?

A. Yes, sir; it probably takes out at least a portion of
 it.

Q. But you can't say the iron takes out any?

A. Not with certainty.

Q. You did discover in the Manhattan Works evi-
 dence that the phenol had been taken out; what you 41
 supposed to be phenol?

A. No; I did not suppose it to be phenol; that is,
 there was an odor there that reminds one of phenol, but
 I do not consider that in sufficient quantity to establish
 its identity.

Q. What could it have been if it was not phenol?

A. A hundred other things; the number of substances
 occurring in gas is so little known that it is not safe to
 decide from the slight resemblance to odor.

42 Q. I understand you to say that the lime process would eliminate the phenol?

A. I think it would probably remove some of the phenol.

Q. How can the oxide of iron method take out the ammonia from the crude gas?

A. I never said it could.

Q. It can't take it out, then?

A. The ammonia is taken out before it comes to the oxide of iron.

43 Q. Does the oxide of iron take it out at all?

A. I think it probably does hold a little ammonia; there is not much in the gas by the time it reaches the oxide of iron; the oxide of iron might withdraw a small quantity of ammonia if there was any in the gas.

Q. Before it left the purifier?

A. Yes, sir; it might do it.

Q. Can't you say with certainty?

44 A. I know there is an affinity between oxide of iron and ammonia, and judging from that, I should suppose it would; and moreover, the oxide of iron smells of ammonia.

Q. I understand from your testimony that you speak doubtfully of the entire removal of carbonic acid by Laming's method?

A. I don't think there is so much doubt about the removal of the carbonic acid by Laming's method; he don't use the hydrate of lime because he uses hydrate of lime with the oxide of iron.

45 Q. Suppose it was subjected merely to the action of the oxide of iron without the hydrate of lime subsequently; what then with regard to carbonic acid?

A. The removal of the carbonic acid would then depend on the possible action of the little ammonia which might be absorbed by the oxide of iron.

Q. Could the gas be subjected to the purification of hydrate of lime subsequent to the iron process, without serious detriment to the candle power of the gas?

A. I think it might.

Q. It has been stated that the iron process does not 46
remove the carbonic acid completely ; is that so ? Has
it never been so stated ?

A. One of our chemical advisers, who is one of the
persons that I understand you propose to bring in, has
made that statement.

Q. Who do you refer to ?

A. Professor Wurtz.

Q. Have you not yourself so stated ?

A. I believe I did.

47

Q. Was it true ?

A. I gave it as an opinion merely.

Q. Have you any reason to change your opinion from
that ?

A. No.

Q. Have you visited the New York Works ?

A. I have.

Q. Do you regard the Rev. Mr. Bowditch as good
authority on the use of coal gas, and the chemistry of
coal gas ?

48

A. I do, except so far as he has a process of his own
for purifying gas.

Q. Is he not regarded as an authority ?

A. With that limitation, yes, sir.

Q. Do you say that there is no disagreeable odor or
smell proceeding from the oxide of iron after it has been
used to purify the gas ?

A. There is not a sufficient amount of odor to consti-
tute a nuisance, as I judge from my own experience.

Q. How much do you think it takes to constitute a 49
nuisance ?

A. Enough to be offensive ; it would probably make
some difference what oxide of iron process is employed,
as there are several.

Q. The oxide of iron process of the New York Works ?

A. That is the one I speak of when I say it is not of-
fensive.

Q. Mr. Bowditch, in his work on coal gas, states as
follows on page 21, with regard to this process of purifi-

50 cation with the oxide of iron. That "it has its drawbacks for consumers ; first, because, since it came into use, much carbonic acid is left in gas, and thus its illuminating power is reduced ; and, secondly, because when the fouled oxide is brought out to revivify, it gives off a quantity of very offensive compounds which seriously annoy those who reside in the neighborhood of a works where fouled oxide is exposed to revivify in the free air instead of covered or nearly closed vessels and chambers." Do you agree with Mr. Bowditch in that ?

51 A. I don't, nor do any of the authorities that I have consulted.

Q. To what part of it do you not agree ?

A. The nuisance of the revivification of the spent iron oxide.

Q. Is that the only part you don't agree with ?

A. Yes, sir.

Q. You don't disagree with him, then, in what he says in regard to the carbonic acid being left in the gas ?

A. No.

52 Q. The Rev. Mr. Bowditch says in his work, as follows: "The aqueous vapors and the vapors of hydrocarbons, are much heavier than the atmosphere, and when evolved from the foul oxide by the heat of chemical action, they float in the lower stratum of the atmosphere near the surface of the earth and produce extensive annoyance." What do you think about that ?

A. The Rev. Mr. Bowditch makes a mistake. One portion of the statement is directly at variance with the
53 facts of the case, for aqueous vapor is only two-thirds as heavy as atmospheric air.

Q. Would not the fog arising from these purifiers of oxide of iron be heavier than the air ?

A. If it was heavier than the air it would not rise. So there is an inconsistency in your question which makes it difficult for me to answer it.

Q. The theory is that it remains floating in the lower stratum of the atmosphere near the surface of the earth ; would not that fog arising from these purifiers float in

the lower stratum of the atmosphere near the surface of the earth? 54

A. That would depend on the condition of the atmosphere at the time as to the movement of the currents.

Q. Well, generally—the general condition of the atmosphere. We don't want exceptional cases?

A. I can only answer from experience that there is not any marked accumulation of gases about the neighborhood of works using this process.

Q. Are not hydro-carbon vapors heavier than the atmosphere? 55

A. Some are and some are not.

Q. Those which are evolved from these purifiers (because I am only speaking about these, it is not in a general broad field)?

A. I think they are, probably.

Q. How do you reconcile the assertion that has been made by the promoters of the iron process, of the entire suppression of the disagreeable smell, with the wholly opposite statements made by other authorities? 56

Q. The only opposite assertions made by any other authority that I know of are made by the Rev. Dr. Bowditch, who has a process of purification of his own to recommend, and as my own experience agrees with the statements of all the other authorities I have consulted, I am at a loss to account for the Rev. Mr. Bowditch's opinion.

Q. Then you know of no other authority than Mr. Bowditch who speaks of the disagreeable odors proceeding from the fouled oxide of iron? 57

A. I recollect of no authority who speaks of them as a nuisance at all.

Q. Does not Clegg say the same thing, sir, with regard to the oxide of iron—of the disagreeable odors arising from it?

A. I don't recollect that he does.

Q. He is a good authority, is he not?

A. Certainly.

58 Q. You don't recollect that he speaks of such odors proceeding from the fouled oxide of iron ?

A. I have not consulted Clegg since last summer.

Q. Since your evidence was rendered have you heard any complaint respecting the quality of gas delivered by the N. Y. Gas Light Company throughout their district ?

A. I saw a complaint in the newspaper which emanated from the laboratory of the chemist of the Manhattan Gas Company ; it mentioned tests made in his laboratory.

59 Q. Is that the only complaint you have heard of the quality of the gas ?

A. I have on one other occasion seen a statement in the newspaper to the effect that something had gone wrong at the gas works, by which the consumers were deprived of their supply of light.

Q. Haven't you heard it stated with regard to the gas, that it was not very pure gas, that it had sulphur ?

A. Only in this instance, which came from the agents of another Gas Company.

60 Q. Have you tested the gas delivered by that company* for the purpose of discovering whether there was any, and if so, what amount of sulphur in the gas as delivered by it ?

A. I have.

Q. What was the result of your investigations on that subject ; did you discover sulphur ?

A. I discovered sulphur every time.

61 Q. How often did you make these experiments ?

A. I have tested the gas on four or five different occasions.

Q. What method did you adopt to discover the presence of sulphur ?

A. The combustion method usually employed ; I have

* The New York Gas-Light Company is the one here referred to, as plain from the context below.—H. W.

also used test paper repeatedly without discovering sulphuretted hydrogen. 62

Q. What quality or proportion of sulphur did you discover on that occasion?

A. The quantity varied.

Q. The sulphur was there I suppose. The occasion of the sulphur being there was on account of the imperfect method of the purification of the gas, was it not?

A. All gas contains sulphur; gas is never perfectly purified. 63

Q. That is not the question. If it was perfectly purified it would be taken out. The method of purification was imperfect, was it not?

A. Yes, sir; it makes me tell something which does not represent the truth when you make me answer that with a single word.

Q. How much sulphur did you discover?

A. I find I have more tests here; I said four or five times, but I had forgotten how many; the quantities of sulphur found in the gas varied from 21 to 45 grains per 100 cubic feet. 64

Q. That is more than is allowed by the English Parliamentary standard, is it not?

A. Yes.

Q. The English Parliament allows what percentage in the gas?

A Twenty grains.

Q. And, therefore, you found more there than is allowed by the English standard?

A. Yes, sir. 65

Q. Now, I am going to ask you this question. You use the gas delivered by the Metropolitan Gas Light Company, do you not?

A. Yes, sir.

Q. Have you tested it to see whether there is any sulphur in it?

A. I have not.

Q. But you have used it in your house?

A. Yes, sir.

66 Q. Have you discovered any sulphur in it?

A. I know there is sulphur in it; I should state so, that I may not appear to misrepresent the facts of the case; I have made some experiments on the Manhattan and Metropolitan gas, but the results determined have not been weighed, so that I cannot tell the figures; the examinations have not been completed.

Q. You say that you discovered sulphur?

A. Yes, sir; there is sulphur in both.

67 Q. As they deliver it now?

A. Yes, sir.

Q. The gas delivered in your house you have not specifically tested to discover whether it contained sulphur or not?

A. It was tested in my laboratory, but not in my house, but the quantity I have not determined in either case.

Q. It is appreciable, is it?

A. Yes, sir.

68 Q. I am going to ask you, as an expert, from what you have known of these various systems of purification, and what you know of the subject matter—as an expert would you advise the Metropolitan Gas Light Company to adopt the iron process without very mature and deliberate inquiry and examination and experiments?

A. I not only would advise them to do it, but I did advise them to fill their four purifiers with the iron mixture, and give the thing a fair trial at once.

Q. You do advise them to do so?

69 A. I do—and I suggested that they should do it.

Q. The question as I propounded it to you is, whether you would advise them to adopt the iron process without mature and deliberate examination, inquiry and experiment?

A. I should; there are reasons why I should.

Q. I will allow you to give your reasons.

A. These reasons are so trifling that it is scarcely worth while to put them on record.

Q. I should like to have them down?

A. In the first place, I consider the iron process more economical ; in the second place, it would do away with the cause of this hearing. 70

Q. That would be entirely satisfactory to the Board of Health ?

A. I am not at liberty to speak for the Board of Health, and I am not the prosecuting attorney.

Q. You think it would do away with the hearing ?

A. I think it would do away with the nuisance, and if it did away with the nuisance there would not be a cause of complaint ; that is my opinion as an expert. 71

Q. Do you know whether the officers of the New York Company are not dissatisfied with this method of the purification of gas, and that it does not come up to their expectations in that regard ?

A. On the contrary, I know that they are pleased with the process.

Q. Did you ever know or hear of an employee or visitor in any of the gas-works being killed by the effluvia from the fouled purifiers ?

A. I think I have heard of such cases, but I could not say with absolute certainty that the sulphuretted hydrogen which killed them was from fouled purifiers, or some other chemical source ; I have heard of persons being killed by escaped sulphuretted hydrogen, but I am a little uncertain whether it occurred in gas-houses or elsewhere. 72

Q. I did not ask you that.

A. I am a little uncertain whether it occurred in the gas-house or where. 73

Q. Did you ever know or hear of an employee or visitor in any gas-works being killed by the effluvia from the fouled purifiers ?

A. I have heard of persons being killed by such foul gases, but I am a little uncertain whether it occurred in gas houses or not.

Q. Or on gas premises ?

A. Or on gas premises.

74 Q. Or that the vapor escaped from the manufacture of gas?

A. Yes, sir.

Q. You can't say that it was. It may have been sulphuretted hydrogen formed under other circumstances?

A. Yes, sir.

Q. Do not mineral poisons, where frequently administered, generally produce some specific disease—salivation, ulceration, &c., &c.?

A. Some do, and some do not.

75 Q. Which mineral poisons do not?

A. Salt—common salt.

Q. Otherwise, do you make any other exception?

A. Yes, an indefinite number of exceptions.

Q. Mercury?

A. Mercury, in a sufficient quantity, will salivate, certainly.

Q. Phosphorus?

A. If you breathe enough of it, it will produce caries of the jaw.

76 Q. Lead produces diseases, does it not?

A. Yes, sir.

Q. Palsy and colic?

A. Yes, sir; and paralysis.

Q. Does not the bisulphide of carbon produce a similar disease?

A. I can only speak from my own experience in that case: that I have been in the habit of breathing bisulphide of carbon frequently, and never suffered any injury from it.

77 Q. State, aside from your own individual experience as a chemist, how is it?

A. Bisulphide of carbon is used so much for filling prisms, and employed by experimenters, and the fact that I have not known it to produce any ill effects, leaves me in doubt of its producing any; I have had it about my own house months together, so that you could perceive it in coming in the neighborhood of it, and never knew of any evil effects from it.

Q. In factories, haven't you heard of operatives getting disease from it? 78

A. Never; I never read of it; some of my old pupils are manufacturers of it too, and I know they do not suffer any injury from it.

Q. According to your own experience, are the employees in purifying-houses of gas-works subject to any special disease or diseases?

A. They are not.

Q. Now, in the cases on record of the poisonous effect from sulphuretted hydrogen, was not the proportion in the air breathed very far greater than any ever occurring in a purifying house, much less in its neighborhood merely? 79

A. It was.

Q. Which do you suppose to be the worse—free sulphuretted hydrogen or sulphide of ammonium free?

A. I don't see much choice between them.

Q. You can't say which is the worse?

A. No.

Q. Is there any? 80

A. I can't say.

Q. Have you ever heard of any person being injured by sulphide of ammonium?

A. I have not; it is a much rarer substance than sulphuretted hydrogen.

Q. Can there be really any sulphuretted hydrogen at all given off by the waste lime, considering that the predominant odor is that of ammonia?

A. I could not answer that question.

Q. This is a bottle of spent lime taken from the purifier of the Metropolitan Works. Now the question is, if you will tell us what is the predominating odor? 81

A. Ammonia. The odor of the second one is that peculiar, persistent odor of gas-lime, which has not been investigated to such an extent as to make it possible to state exactly what it is.

[The counsel produces two bottles of spent lime taken,

82 one taken from the top and the other from the bottom of a fouled purifier of the Metropolitan Gas Works.]

Q. Is there ammonia there also, doctor?

A. I think I perceive ammonia.

Q. Try it again?

A. I think there is ammonia there.

Q. Is there not an excess of ammonia?

A. I think there probably is.

Q. Try, doctor, long enough to know whether there is an excess of ammonia there?

83 A. I think there is probably some ammonia there.

Q. An excess of it?

A. I think so.

Q. Is there any doubt about it?

A. I think not.

Q. You have subjected it to another test?

A. Yes, sir.

Q. To what test?

A. Turmeric paper.

84 Q. Doctor, can there really be any free sulphuretted hydrogen of the kind supposed to be thrown off by the waste lime, considering that the predominant odor is that of ammonia?

A. Not until after the ammonia has escaped.

Q. Is there any evidence that there is any poisonous substance given off by that lime?

A. Yes, sir; I think there is.

Q. What is it?

A. I think there is sulphide of ammonia escaping from the mixture.

85 Q. Did you ever know of sulphide of ammonium poisoning anybody?

A. No, I never did.

Q. Did you ever hear of anybody being poisoned by it?

A. None.

Q. Then why did you say it is poisonous?

A. Because it has such a disagreeable effect on my nose and lungs.

Q. Is not almost every human being subject every 86 day, more or less, to the inhalation of sulphide of ammonium, or even at times sulphuretted hydrogen, from his own excrement?

A. He probably is.

Q. Are scavengers who handle such matters subject to any special morbid condition?

A. They are occasionally killed by the foul gases of cesspools they enter.

Q. Are they subject to any special morbid condition?

A. Would death come under that head? They are 87 occasionally killed by the effluvia.

Q. That is the the only answer you can give to it?

A. Yes, sir.

Q. Is it not an accepted maxim that the effluvia from human excrements, unless putrid or tainted with a disease like cholera, never hurts any person?

A. I never heard of any maxim relating to it, but I never knew the fresh excrements to do any harm. After a short time they certainly do have that effect. We know that the camps during the war became terribly 88 offensive from the accumulation of that sort of thing.

Q. Is not sulphide of ammonium a recognized constituent of the effluvia from such substances?

A. I can only say that I have not paid especial attention to that department of science.

Q. What is the effect of leaving sulphur compounds in gas?

A. That depends somewhat on what particular compounds are left in the gas.

89

Q. Sulphur compounds?

A. There are different sulphur compounds; some have one action, some another.

Q. When the gas is burned?

A. When combustion takes place they produce sulphurous acids and sulphate of ammonia.

Q. Is that first product of which you speak deleterious to health or not?

90 A. Not in small quantities, which are evolved from the wholly purified gas.

Q. Gas that contains 21 grains ?

A. No, sir.

Q. Not injurious to health ?

A. No, sir.

Q. Not detrimental ?

A. No, sir.

Q. Or to property ? How does it affect property ?

A. Or to property.

91 Q. What was the experience in the early days before the lime process was introduced, in regard to the effect of gaslight on health and property ?

A. The enormous quantity of sulphur in the gas at that time was a source of inconvenience, I believe.

Q. Did't it injure property, books, and maps ?

A. It was claimed that books suffered from it.

Q. Was not its use prohibited in the British Museum ?

A. I cannot say that it was.

92 Q. Is there not an especial danger pertaining to sulphurous acid gas, arising from its comparative freedom from odor ?

A. It is not comparatively free from odor.

Q. You deny the premises ?

A. I deny the premises. It has, on the contrary, a most suffocating odor.

Q. What is the effect of it upon your eyes, lungs and mouth ?

A. In a concentrated form it is suffocating, and in the small quantities which gas is liable to put in the atmosphere, it is inappreciable. I have not smelled or perceived the sulphurous acid, even from the most impure gas that I ever saw burned.

Q. Do chemists hesitate to expose themselves to sulphuretted hydrogen or sulphide of ammonia ?

A. Not when they are diluted.

Q. Do they hesitate to inhale sulphurous acid ?

A. Not when it is diluted.

Q. Do you make any distinction between them ?

A. No, sir.

94

Q. Do they hesitate any more to expose themselves to inhaling sulphurous acid than they do sulphuretted hydrogen or sulphide of ammonia?

A. Only in so far as the sulphuretted hydrogen or sulphate of ammonia are more disagreeable when presented in small quantity.

Q. Are they as injurious as the other?

A. In minute quantities, I consider that sulphuretted hydrogen and sulphide of ammonia are most injurious.

Q. What is the action of lime on the bisulphide of carbon in the gas? 95

A. I don't know that it has any action.

Q. What is the action of oxyd of iron on it?

A. I don't know that it has any action; I answer your question, supposing you to mean at ordinary temperatures.

Q. The Rev. Mr. Bowditch says, in his work, on page 27, "At common temperatures hydrate of lime forms with bisulphide of carbon, a very beautiful ruby colored crystalline salt." Do you agree with the Rev. Mr. Bowditch in that? 96

A. I have never examined the question.

Q. You don't know whether he is correct or not there?

A. No.

Q. Do you know Brezelius?

A. I have read him.

Q. Is he a good authority?

A. Yes, sir.

Q. Brezelius says, "By digesting sulphide of calcium with an excess of bisulphide of carbon and water at 30 degrees in a glass vessel, a dark ruby liquid is obtained, and this, when evaporated in vacuo, yields a mass which is yellow, brown and crystalline at first, but assumes a pale yellow color when perfectly dry." Do you agree with Brezelius? 97

A. Yes, sir; I accept whatever Brezelius says, unless I know to the contrary.

- 98 Q. If you accept that, does it not necessarily follow that the lime purifier extracts the bisulphide of carbon?
 A. It doesn't necessarily follow.
 Q. Why not?
 A. In the first place, the conditions were not the same.
 Q. If the conditions were the same?
 A. If the conditions were the same, and there was no other reason for some other change taking place, that might happen.
- 99 Q. What conditions are not the same?
 A. In the first place, Brezelius had an excess of water; he speaks particularly of the excess of water; that might or might not modify the reaction.
 Q. I understand you to admit that the Rev. Mr. Bowditch states that at a common temperature hydrate of lime forms with bisulphide of carbon a very beautiful ruby color crystalline salt?
 A. I accept that substantially.
- 100 Q. Now, if you accept that, and if that is true, will not the lime process extract the bisulphide of carbon?
 A. It will probably extract a portion of it.
 Q. Are you aware that the Metropolitan Gas Company scrub their gas copiously with cold water before condensing it?
 A. I am aware of it.
 Q. I want you to say what effect has this scrubbing on the offensive compounds?
 A. It undoubtedly removes a portion of them.
 Q. It carries them off—those at least which are condensable in water, into the tar well?
- 101 A. A portion of them, not all of them.
 Q. That proportion, of course, is prevented from going into the purifiers at all.
 A. Yes, sir.
 Q. What effect would it have, for example, on the acetylene, in the gas; would it not remove it?
 A. It would probably remove a portion of it; it don't take all of anything out of the gas.

Q. Does it not take out the tar ? 102.

A. A portion of it ; the greater portion of it. I should qualify that, because a very small portion of tar goes to the water at all, it is separated before the scrubbing by water is resorted to, and I suppose it takes out a very small portion of the tar.

Q. Would not the washing with water increase the quantity of tar in the water itself which was extracted ?

A. The water would extract a little more, which would otherwise be left in the gas.

Q. Does not the tar contain all the offensive ingredients of the gas ? 103.

A. It contains portions of most of them ; that is to say, all the impurities are not all in the tar.

Q. Then this scrubbing process does perform a very sensible office in the purifying of the gas ?

A. Yes, sir.

Q. And, of course, prevents them from going into the purifiers with the waste lime ?

A. Yes, sir.

Q. Otherwise, if they went into the waste lime there would be more work done there, and that process purifies the gas to that extent at any rate ? 104

A. Yes.

Q. The washing process, to a considerable extent ?

A. Yes, sir.

Q. If you put a woolen cloth or blanket in the atmosphere containing these foul vapors, will it not absorb and contain them for a considerable time ?

A. I suppose it would. 105

Q. Is there any doubt about it ?

A. No, I think not ; I think it would.

Q. What are the properties of acetylene as to smell ?

A. I believe it has a disagreeable odor ; but I never smelled it.

Q. Do you know what becomes of it when the gas is burned ?

A. I suppose it is burned in the gas.

Q. Do you consider Berthelot good authority ?

106 A. He is a noted chemist.

Q. Berthelot says that "coal gas is no exception to this general rule—a rule that has been stated—as may be easily ascertained by observing the traces of acetylene which it contains in its normal state. It is produced and discharged into the atmosphere whenever an organic compound burns in contact with the air with the formation of lamp-black." Do you agree with Berthelot in what he says about that?

107 A. I can only say I have perceived that odor which Berthelot attributes to acetylene, but have no other evidence in the matter.

Q. Berthelot says further as follows: "The same observations are applicable to the composition of coal gas. The gases discharged into the air, whether by the flame of a burner known as the bat's-wing, or by the smoky flame of one of Bunsen's burners, contains a notable portion of acetylene." How does that agree with your experience?

108 A. I have perceived the odor from the smoky column of Bunsen's burners, but I have not perceived it from any ordinary gas burner used for illuminating purposes, when not improperly used.

Q. If these statements are correct, would you not object to gas as served, on the ground that it contained acetylene?

A. No. I see no reason for objecting. My wife does not object to the tea kettle apparatus on that account.

109 Q. Is it not probable that the presence of carbonic acid in the gas might interfere with its complete combustion, and conduce to the formation of acetylene and carbonic oxide and similar offensive or poisonous products?

A. Yes, if present in sufficient quantity.

Q. I will ask whether the emanations from the spent lime are injurious to the health of the community in which they are evolved?

A. I think they are, because they nauseate.

Q. Is everything which nauseates injurious to the health? 110

A. I think it is, unless a person desires to be nauseated for some other difficulties.

Q. And everything that is nauseating is a nuisance?

A. Yes, unless it is resorted to to produce a nausea for a specific object.

Q. Do you mean to say that you have been nauseated by the atmosphere of the purifying house of the Metropolitan Gas Company, for example?

A. Well, I am not enough of a medical man to say 111 what nauseating is, but I have been highly disgusted by the smell, and that is what I have understood medical men to understand by the word nauseating. I have not actually been made sick at my stomach, but I have had those impressions which are preliminary to that feeling.

Q. Did you ever know any person that was nauseated—any chemist, by breathing in the laboratory the sulphide of ammonium?

A. Nauseated, in the sense which I understand it there, I have; the effect that a highly disagreeable odor 112 has upon a person.

Q. Do you mean that these odors which escape from the spent lime are anything more than that you have said is disgusting to you—do you mean that?

A. I mean that they are highly disgusting, and what people call nauseating. I am not a physician, and do not pretend to be an expert in medical terms.

Q. You do not mean to say they are detrimental to health? 113

A. I do, because I think it is detrimental to health to be constantly nauseated.

Q. You do not think that there is anything poisonous?

A. Anything that produces that disagreeable effect is called a poison, and it is a poison.

Q. Have they the ability to create a disease as a poison does?

A. The term poison is so indefinite, I should prefer to say I consider them injurious to health.

- 114 Q. Now, I beg you to state why they are injurious to health, in your own language ?
 A. Because they nauseate in the sense I have used the term.
 Q. In no other sense ?
 A. Not to my knowledge.
 Q. Have they no fermenting properties ?
 A. No.
 Q. Most poisons have, have they not ?
 A. No.
- 115 Q. How is the odor of roses to you ; agreeable or disagreeable ?
 A. In a moderate quantity it is agreeable, though not my pet perfume.
 Q. You know that persons are made sick by the smell of roses, even in small quantities ?
 A. Yes.
 Q. The same way with regard to the smell of strawberries ?
 A. Yes.
- 116 Q. Makes a good many people sick, does it not ?
 A. Yes.
 Q. And to others it is delicious ?
 A. So I have understood.
 Q. There is no doubt about that ?
 A. I think not.
 Q. You would not ask to have them suppressed because they are disagreeable ?
 A. That is so rare.
- 117 Q. Have you not heard that there are whole peoples to whom the smell of roses is disgusting and oppressive ?
 A. Never heard of it.
 Q. In Italy, for example ?
 A. Never heard of it.
 Q. Do you compare these exhalations from the spent lime purifiers with exhalations which are known to be poisonous in minute quantities—like miasmatic exhalations, or those from putrid organic matters ? How is that, Doctor ?

A. I do not compare them with those exhalations 118
which are supposed to be organized, and develop specific
diseases.

Q. Are not the latter believed to be of the nature
of ferments or organized germs capable of reproduc-
tion?

A. They are by many persons.

Q. Is mere foulness of odor indicative of poison?

A. Poison is an indefinite term.

Q. Is mere foulness of odor then indicative of poison-
ous qualities, or as positively injurious to health? 119

A. I think it is so.

Q. Which?

A. I think foul odors are, as you say, injurious to
health.

Q. As I understand you, you do not compare these
exhalations from the lime purifiers, with the exhalations
known to be poisonous like miasmatic exhalations, etc.,
you do not class them in the same category?

A. No, sir.

Q. Will you please to state with what known sub- 120
stances or injurious properties you do compare them in
giving them the character you have, which are injurious
in excessively minute quantities?

A. I compare them with sulphide of ammonium and
sulphuretted hydrogen.

Q. I understand you to say, that you never knew in
your experience, or heard of any persons who had been
killed by breathing one or the other; or that they had
ever incurred any disease by breathing it? 121

A. I made that statement.

Q. Do you consider the British Association of Gas
Managers a body qualified to consider the subject of the
purification of gas?

A. Undoubtedly.

Q. In the inaugural address of the president of that
body, Thomas Hawksley, Esq., on the 11th June, 1867.
Have you seen it, Doctor?

A. No.

122 Q. The president says, in that address, in speaking of purification, as follows :

"If there be one thing more injurious than another to the person by whom gas is consumed, it is the presence of sulphur in any amount in the gas, at the place where it is employed."

What do you think about that statement of President Hawksley's ?

A. I do not think that President Hawksley is any more competent to judge upon that point than myself.

123 Q. He regards the presence of sulphur in any amount as injurious. Do you agree with him ?

A. I do not agree with that, unless he means the presence of a large quantity. If he means the presence of any sulphur, I disagree with him ; if of a large quantity, then I agree with him.

Q. I will read to you from this same address of President Hawksley, as follows :

124 "I think we shall all be agreed in the desirableness of adopting some means, if such means can be discovered, for the removal of this noxious material. Permit me, then, to mention to you merely as a subject for your consideration ; for you all know a great deal about it—that the use of oxyd of iron, which is in itself a very valuable material for the ordinary purification of gas from sulphuretted hydrogen, is insufficient, and a great deal of the obloquy which has fallen upon gas companies during the last few years, has arisen from the adoption of that material, in substitution for the old mode of purification. We all know that lime is very liable to, and in all ordinary cases, does give off an obnoxious smell in the neighborhood ; but it, undoubtedly has this property, that if it creates a smell by reason of its being kept on the gas works, it prevents a much more serious smell in the houses of the consumers, for what you fail to take out of the gas by the oxyd of iron in substitution of the lime, really goes into the dwelling houses, and manufactories, and shops of the consumers, in the form in which I exhibit, com-

125

bined of course with the gas, but still, in every thousand cubic feet of gas there is a large quantity of sulphur to be burned in the interior of the building where the gas is distributed. Under these circumstances, great attention has been paid to the elucidation of a better chemistry on this subject, and it has been ascertained by Dr. Letheby, as the result of a great number of experiments, made upon a very large scale, a considerable portion of which were conducted in the town—that whereas by the use of oxyd of iron, you cannot remove the whole of the sulphur, but must leave 127 in the gas from 20 to 25 grains in every 100 cubic feet, yet by the use of lime alone, you may reduce that quantity down to less than one half; in fact, you may reduce it down to from 10 to 12 grains.”

Now, Dr. Chandler, the question about these extracts is, whether you agree with the president in these statements?

A. There are so many statements there—while I agree with some, I do not agree with others.

Q. State what you agree with and what you do not agree with. 128

A. I agree with the probable effect of lime in removing more sulphur than is removed by the oxide of iron, but on the other hand, I consider what is said about the effect of these few grains of sulphur more or less in the gas, to be highly ridiculous and absurd; and am supported in this by the opinion of prominent chemists.

Q. Does not the sulphur have the effect to nauseate? 129

A. Not in the maximum quantity which occurs in the gas; it will not have the effect to nauseate.

Q. Do you not know that the British Parliament have passed an act in which it is provided that the gas delivered shall be freed from these small quantities?

A. They have passed such an act; and they have passed a great many other ridiculous acts—the “Stamp Act,” and several others.

Q. Then you regard the act of the British Parliament,

130 as a sanitary measure, in the same light that you do the act of the British Parliament imposing "stamp duties?"

A. I do not say it. I say, it does not follow that, because the British Parliament fixes it at twenty grains, that it was necessarily the proper limit. I know that the reason that led them to fix it at that point was insufficient.

Q. You say that, notwithstanding all that you have said, the lime process of purification is the process which is in use in all the large cities of the United States?

131 A. Yes.

Q. Including the city of Philadelphia, the gas for which is manufactured and purified by the municipal corporation itself?

A. Yes.

Q. Where does the purification of gas by the iron process prevail?

A. In all the large cities of Europe.

132 Q. Are you not aware that in communities where this process of purification by iron has been adopted, that it has proved to be a failure, and that the companies that have adopted it are, in many instances, abandoning it, and are returning to the lime process of purification. Have you not been so advised?

A. I have been advised that the iron process is still in use on the continent of Europe; but that, owing to this foolish law of the British Parliament, the gas companies have been so hampered—the iron process not allowing them to keep within the act—I have heard that on that account, they would return to the lime process.

133

Q. As a process which would enable them to deliver gas of the purity required by the act of the British Parliament?

A. Yes.

Q. And will you not say as an expert, that the lime process does deliver a purer gas to the consumer than the process of the oxide of iron?

A. I think it does.

Re-direct examination of Prof. Chandler was deferred. 134

Prof. Benj. Silliman, Jr., called for the Metropolitan Gas Light Co., being duly sworn, testified as follows :

Q. By Judge Van Vorst: State, if you please, your profession ?

A. I am a chemist residing at New Haven, and have charge of the department of general and applied chemistry in the Academical Department of Yale College. I have been connected with the institution since 1847, as a professor, and since 1838 as a teacher. 135

Q. Have you given particular attention to the subject of the manufacture of coal gas ?

A. I have been practically familiar with the manufacture of coal gas for about twenty years.

Q. Have you studied the subject of its purification ?

A. I have.

Q. And have you observed it practically ?

A. I have observed it practically.

Q. What is the method of purification in the United States, as far as your knowledge and experience goes in that subject ? 136

A. The usual method of purification of gas in the United States is what is familiarly known as the dry lime process, in which the hydrate of lime is employed ; and there is in use in a few companies, what is known as the wet process, in which the gas is first passed through a salt of iron, green vitriol, and then through milk of lime under pressure, under weight of machinery. I might further answer your question by saying that, so far as I know, there is but one company in the United States that employs the iron process, which is the usual process in Great Britain and on the continent of Europe. 137

Q. What is the company you speak of ?

A. I think it is called the New York Gas Light Company. It is the old company. I visited their works last summer.

Q. You have visited the Philadelphia company's works ?

138 A. I have visited the Philadelphia Company several times.

Q. You have witnessed their process?

A. Yes, sir. I have been familiar with several gas works, particularly Boston, Worcester, Hartford, New Haven and Louisville.

Q. Have you been in Prof. Smith's establishment at Louisville?

A. I have, recently.

Q. Since his return from the World's Fair?

A. It was about the first or second week in September I was there. He uses the dry lime process.

Q. You have witnessed the purification of the New York works, what, in your opinion, is the best mode of purification of gas?

139

A. I have no hesitation in saying that, if properly conducted, the dry lime process offers by far the best means of purification.

Q. Why?

A. For several reasons, first, because it does effectually remove all the sulphur which is in a state of chemical combination, such as is capable of being removed on a large scale by any known process. I might make an exception of Dr. Bowditch's method. I know nothing about his method practically. I except, of course, in this generalization, the sulphur combined in such forms as to escape the ordinary tests employed to indicate its presence. This process does effectually remove the carbonic acid, which no other known process does remove.

140

Q. Any other reason, Professor?

A. I do not think of any other. As regards ammonia, I do not know that it is more efficacious than other processes, and believe it is less efficacious than the process of wet lime with the salt of iron, which does remove all the ammonia.

Q. The most deleterious substance or element to which your attention is directed in purifying the gas—does it not seem to be sulphur?

A. Yes, sir. In its various forms of combinations, it 141
is the black beast of the coal gas manufacturer.

Q. And which you seek to eliminate?

A. And which we seek to eliminate. You will observe I made an important distinction. I said if applied with suitable precaution.

Q. It more effectually removes the sulphur?

A. More effectually removes the sulphur than any other available process.

Q. What objection, if any, exists to the dry lime process? 142

A. The objections to the dry lime process are two-fold: first, that the material is exhausted, and, to a great extent, lost in respect to its value in the act of purification, and that no process has yet been discovered by which it can be restored to a condition to purify gas again. That is a loss which falls upon the company.

Q. Anything else?

A. Second—that this accumulation as an effete waste product about the gas works, as ordinarily conducted, 143
constitutes a just ground of complaint as a nuisance, using the term nuisance in the sense of that which is offensive.

Q. Offensive to the smell?

A. Yes, sir. I classify nuisances under two general heads—those which are offensive to the sense of smell, and as such repulsive to our sense of taste; others which are deleterious and noxious as regards health. In the first class I would arrange gas works and stables among causes of that kind; and in the second I would place all 144
such nuisances as bone boiling establishments and glue establishments, and others where putrescent animal matter is the subject of treatment; which are decidedly and confessedly injurious to public health.

Q. You do not consider the emanations from the gas works of which you have spoken as deleterious to health?

A. A long familiarity with the management of the New Haven Company, with which I have been associa-

145 ted as a director, has satisfied me that no injury to health—no bodily injury—attaches to the use of dry lime. By diligent inquiries, the only complaint I have heard was, some irritation of the eyes of the persons about the boxes, when they are opened. That proceeds from the ammonia, and is entirely transitory. On the contrary, parties living in the immediate vicinity of these works, have always asserted that they have enjoyed excellent health.

Q. Then you do not regard those exhalations or emanations as deleterious to health?

146 A. I do not. I should like to distinguish, however, between the classes of emanations which are given off in the decomposition of effete lime. I would call your attention to what seems to me an important distinction that exists between two quite distinct groups of exhalations, viz.: that the first effect of the atmospheric air upon the effete mass, is an effect of oxydation, resulting in a state of high temperature, the whole mass of the effete lime becoming so hot that you cannot conveniently bear
147 your hand in it, and this process of oxidation accompanied by the production of watery vapor and free ammonia, which exercises a stimulant effect, such as is due to this active agent; and second, an entirely distinct class of effects is that which arises from the gradual separation at a later stage of the process, of highly offensive hydrocarbons, probably containing sulphur as one of their constituents, and characterized by an extremely persistent odor. This latter class of odors I have observed is not developed in the earlier stages of
148 the decomposition of the mass. There is always to be perceived during the process of oxidation, as alluded to, the odor of sulphuretted hydrogen escaping from the decomposition or combustion of the sulphide of ammonium; but this odor of sulphuretted hydrogen or sulphide of ammonium, is restricted to a radius of limited extent—measuring from the purifying box as a starting point, and soon disappears. There, sir, is a sample of lead paper, prepared this morning, in the yard of the Metro-

politan Gas Company, by exposing the paper, when 149
 moist, to the atmosphere of the yard, at a measured distance of 40 feet from the building, and in close proximity to one of the telescopic holders of the yard. Here is another lead paper, prepared in precisely the same manner, which was exposed at a distance of 60 feet from the windows of the purifying houses, the wind blowing from the direction of the house strong over the paper. Here is another paper of precisely the same kind, which was exposed at the measured distance of 70 feet from the 150
 same point. All these measurements were taken from the same point; and here is a fourth, at a distance of 75 feet northeast. I think you will perceive distinctly, a diminution of the intensity of the action of these sulphur compounds with this moderate increase of distance. The last is very slight—scarcely perceptible.

Q. At a distance of seventy-five feet from the works, the wind blowing from the purifying house, it scarcely discolored?

A. It scarcely discolored the lead papers. I should 151
 remark, that these lead papers were all exposed in a moist state, and remained there exposed until they had dried off in the wind, which was about 15 or 20 minutes.

Q. You mean that the sulphide of ammonium evolved from the lime was so diffused at the distance that it made a very slight impression upon the paper?

A. Yes, sir. Another very characteristic odor of the effete lime—spent lime—is that which is attributable to naphthaline—a substance which is always found to a greater or less extent in connection with spent lime, and 152
 which develops itself frequently in the latter stages of the decomposition—some weeks even after the material has been exposed to the action of the air. This beautiful pearly and micaceous substance appears in the brilliant crystalline plates, lining the cavities or covering the surface upon the spent lime, and its odor is, likewise, clearly perceived at an early stage, when the box is first opened. The odor of naphthaline is agreeable to me. It is employed in small quantities as a perfume.

153 I will exhibit some samples I picked out of a heap this morning from the pile of spent lime which had been exposed some three weeks. You will see, that is perfectly filled with those beautiful scales of naphthaline.

Q. You were at the Metropolitan Works when the purifiers were opened?

A. I was.

Q. This morning?

A. Yes, sir. They had one opened specially for our inspection, and which had been running, I was informed, 154 41 hours prior to the time when we saw it opened; and that there had passed in that time, by the registration of the station meter, one million feet of gas.

Q. What was the state of the atmosphere there this morning, when you were there?

A. The outer atmosphere was bright, and clear, and cold. The atmosphere of the room, before the box was opened was not disagreeable; and when it was opened, there was an odor of naphthaline, and for some little time, I could perceive nothing else. Very soon, however, the powerful action of oxidation set in, and the 155 lime began to give off vapor of rather a strong odor of ammonia, overpowering everything else.

Q. Is ammonia deleterious to health?

A. It is estimated the reverse.

Q. It is a stimulant?

A. Yes sir; administered to revive fainting persons.

Q. Was there any sulphide of ammonium present?

A. Undoubtedly.

156 Q. How much?

A. It is impossible to form any more than an empirical judgment as to that. The nose is a poor analyst. Undoubtedly there is a large quantity of sulphide of ammonium.

Q. In this connection, now I will ask you, what are the objections to the iron process of purification?

A. The principal objection as I conceive to the iron process, is that it is less efficacious in general, as a means of purification than lime. It does so efficaciously remove

the free sulphur. It does not effectually remove the 157
carbonic acid. It does not effectually remove the ammonia.

Q. It it does not effectully remove phenol ?

A. That I cannot speak of from my personal knowledge.

Q. State the objections to the process ?

A. There is this principal objection ; I conceive that in every metropolitan gas works, it is the bounden duty of the company to exercise all possible diligence to avoid the nuisances which are sure to manifest themselves, whatever agents may be employed for purifying, 158
and for this purpose, there is no means hitherto discovered that appears to be so efficacious as the method of ventilation which has been recently adopted by the Manhattan works in this town, and this process of ventilation appears to be inapplicable to the iron process for the important reason, as it appears from the writings of Mr. Clegg and other English authorities, that the heat generated by the active chemical efficiency of the oxygen, is created in such an amount as to heat the 159
mass to redness and set fire to the wooden screens and destroy the apparatus, while in the case of spent lime, ventilation restores it to a condition inoffensive to health and leaving a product which, as I conceive, has high value for agricultural purposes. I shall present a specimen of spent lime which I took from one of the boxes of the Manhattan works, which represents fairly the mass of the material as it exists in the boxes. There is a feeble odor, slightly of ammonia and slightly of gas tar, 160
but it is not an offensive material. I speak of it in a large way. It consists chiefly of sulphate and sulphate of lime, with some free lime called hydrate of lime, and is, therefore, a mixture which the agriculturists may employ with great advantage as a fertilizer, which is not true of the spent lime—of the dry lime process, as it is ordinary sold by gas companies for such uses.

Q. What odors does the effete iron give forth after it has purified the gas ?

161 A. My recollections of the visit which I paid to the New York Company last June or July are not very distinct; but my recollections are that the mass smelled of ammonia, and that there was, also, to some extent, the usual familiar odor of the gas-house, but decidedly to a less extent than in case of the lime purification.

Q. Were they nauseating or disgusting in their character—did they have that tendency?

A. I could not say that they had; at the same time I ought to state, in that connection, that my attention was
162 not so much directed to any question of the sanitary effect as to the economic one as affected by the iron process in place of the lime process. I went there expressly as a director of the New Haven Company—in that point of view.

Q. You concluded not to adopt it?

A. Concluded not to adopt it. I was not satisfied with the degree of purification.

Q. Do I understand you to say that the oxide of iron fails to eliminate the sulphur in the various forms in
163 which it exists in the gas?

A. Not in so broad terms. I say that it fails to eliminate it to the same extent as lime does.

Q. Have you observed, since you have been in New York, the gas delivered by the Metropolitan Gas Co.?

A. I have this morning, and measured it with the photometer. I also tested it with lead paper to determine the presence or absence of free sulphur compounds, and found none.

Q. Is there not, as yet, much obscurity in the minds
164 of chemists generally, about the complete nature of the action of the lime—the complete composition of the waste and the effluvia therefrom?

A. I do not know of any thorough chemical research upon the whole subject of purification of gas; and certainly think there are many important questions connected therewith that need further examination.

Q. In a sanitary point of view, do you think the purification by the oxide of iron has any advantages over the lime process of purification?

A. Not if the lime process is conducted with suitable precaution; on the contrary, I conceive that in the aggregate the annoyance and injury to property which results from impure gas. 165

Q. I am speaking in a sanitary point of view?

A. It affects the health. The respiration of air in a close room affects the eyes and the organs of respiration by reason of the presence of sulphurous acid or sulphate of ammonia, or both, which may be present, is given out in the progress of combustion, and which ought to be removed, in a great measure, in the purifying house. 166

Q. In a sanitary point of view, comparing these two processes of the purification, and the quality of gas delivered by them respectively, do you not give the preference to the lime process of purification over that of iron?

A. With the same explanation as before—that the lime process, conducted in a proper manner, I think is capable of producing the best results for the public good.

Q. State, if you please, what is your own personal experience in regard to the burning of gas charged with sulphur in a close room? 167

A. I have often observed that, upon placing my head in an elevated position, as upon a step ladder or any other means of reaching the upper portion of the room where numerous gas-lights were burning, there was a very decided irritation to the organs of respiration and to the eyes; and resulting, as I conceive, (and know in fact,) from the production of ammoniacal salts and of sulphurous acid. I find ammonia to be a much more frequently occurring impurity in gas than most writers report. 168

Q. Is not sulphide of ammonium a very unstable, perishable and transient substance in the air?

A. I have reason to suppose that sulphide of ammonium is rapidly oxidized by the action of the atmosphere with the production of free sulphur and water, of course.

Q. Is not sulphuretted hydrogen quickly destroyed by the air?

169 A. It is. I have observed that, in visiting the natural sources of sulphuretted hydrogen; such as the famous baths in the neighborhood of Rome, and other lakes and springs, that the odor of sulphuretted hydrogen does not penetrate, nor is it carried to any great distance from the springs.

Q. Is there any sulphuretted hydrogen concerned in this case at all?

170 A. No, sir; I cannot conceive of the existence of sulphuretted hydrogen, as such, in a free state, in presence of an atmosphere so highly charged with free ammonia, as we find that to be where a dry lime purifier is freshly opened, and the process of atmospheric oxydation has set in. I might add in that connection, the sulphur compound which affects the lead paper I conceive to be, generally, if not exclusively, sulphide of ammonium. This lead paper is the only guide which the gasmaker employs to determine when the gas is sufficiently purified to be sent to the consumer, purified from the sulphur, of course.

171 Q. Did you ever know or hear of an employee or visitor in any gas works being killed by the effluvia of the fouled purifiers, or injured thereby?

A. Never.

Q. What is the state of health of those persons who are concerned in and about your purifying house, in the New Haven works and other places?

172 A. I think I have answered that question. I should say in general that I have always made diligent inquiries wherever I have been, about the health of the persons employed about the purifying houses, and the answer has always been, that their health was excellent.

Q. You do not know that they are subject to any particular diseases?

A. No sir. There is a prevalent opinion, which may be worthy of record, that in time of epidemic diseases, such as cholera and yellow fever, they do not prevail in the vicinity of gas houses. I heard that opinion ex-

pressed very confidently in New Orleans twenty years ago, where the yellow fever is very prevalent. 173

Q. What do you attribute that to?

A. I conceive it must be attributable to the specific medical effect of some of the products of the distillation of coal, of which I would name carbolic acid, which is the same thing as phenol, as the most perfect representative of that class of agents which are most destructive to the spores and germs of fermentation of fungoid growth to which some physicians, with some confidence, attribute epidemic diseases. 174

Q. Has the presence of sulphur anything to do with it?

A. Sulphurous acid is well known to act in the same manner as an efficient agent in the destruction of germs and spores which produce ferment and disease, and sulphur itself, as such, is largely employed for the destruction of mildew. I do not know that sulphur or sulphurous acid either, in this case of gas works, has any application. 175

Q. Are the emanations or exhalations from the spent lime, when the purifiers are opened, poisonous or deleterious to health?

A. I should say, decidedly not deleterious to health—that would open the question of what you mean by poison.

Q. Deleterious to health?

A. I think a man would speedily be killed in an atmosphere of pure ammonia.

Q. Whether the process of manufacture of gas by the Metropolitan Gas Company, as you have observed it, gives forth any deleterious gas or odor detrimental to health? 176

A. No.

Q. How would you compare these exhalations or emanations from organic substances which produce those disagreeable odors which you speak of as from bone-boiling houses?

A. I can say that, in all cases where putrescent ani-

177 mal matters are undergoing transformation, there are emanations which may be, and in many cases probably are, decidedly detrimental to public health. It is well known that those emanations excite putrescence in other substances, causing milk to pass rapidly into acetous and putrefactive fermentations. I have no doubt that a carcass, as of a sheep, hung up in the purifying-house of a gas works, would escape putrefaction very much longer than when hung within a short distance of one of those sources of animal contamination, or even a tenement
 178 house. It is well known to chemists that animal substances are prevented from passing into a state of decay by being simply exposed to gaseous exhalations of gas possessing antiseptic properties, such as sulphurous acid and phenol, and carbonic oxyd. It is well known that meats or dead bodies washed with phenol escape for a long time the action of putrescence, and for the same reason coal tar is an antiseptic, because it contains several of these substances.

Q. I ask you this: whether you observed, in the
 179 neighborhood of the Metropolitan Gas Works any cause which would be likely to produce these contaminating or deleterious odors of which you speak?

A. When I went down 42nd street this morning, before I reached the works, the wind blowing strong from the water towards me, I perceived very decidedly the odor of decomposed animal matter. The familiar odor of bone boiling or fat houses, or piggeries, or all combined. I did not know what source it came from, but I called the attention of my companions to the fact that there
 180 was a stench which many persons in their ignorance might attribute to the gas-house, which was not far off, but I was very particular to remark, that it was clearly attributable to some cause to me unknown, like the house or manufactory alluded to. I was informed that there were, in that direction, below me, places of that kind—I believe a piggery or bone-boiling place, but I did not visit them.

Q. How soon after reaching 42nd street did you notice these odors?

A. After I left Tenth avenue, I noticed it before we 181
had passed one hundred feet. It evidently proceeded
from the direction of the wind, which was blowing out
of the southwest at that time.

Q. And had its origin in decomposing or decomposed
animal substances?

A. It so addressed itself to my senses.

Q. And it had none of the properties peculiar to gas or
its manufacture?

A. None whatever.

Q. And those you would say were detrimental to 182
health?

A. Such I conceive to be detrimental to health.

Adjourned to Saturday, Feb. 13th, at 10 o'clock.

BEFORE THE BOARD OF HEALTH. 183

IN THE MATTER

of

The application of OSCAR ZOLLIKOFFER, President of the Metropolitan Gas-Light Company, for the modification of the order No. 425, dated July 14th, 1868, of the Metropolitan Board of Health, concerning the business of Manufacturing Gas at the foot of West 42nd Street, New York.

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NEW YORK, February 13th, 1868.

CONTINUATION OF THE HEARING BEFORE S. C. HAWLEY,
REFEREE.

Ex-Judge H. C. Van Vorst appeared for the Metropolitan Gas Company.

J. S. Hastings, and George Bliss, Jr., appeared for the Board of Health.

Professor *Benjamin Silliman*, re-called. Examination resumed by Judge Van Vorst : 185

Q. Professor Silliman, you spoke about having visited the gas works in Boston, Philadelphia, and in some other places—state, if you please, in what part of the city those gas works are located, as to their being surrounded by population ?

A. The densely peopled part of the old town of Boston, is the location of the gas works there.

186 Q. How in the other place?

A. The Northern Liberties Works in Philadelphia, which is an independent corporation not owned by the city, is also in a densely settled portion of the town; there are, at present, I believe, three distinct gas works in Philadelphia, not under the management of the corporation; I have not visited all of these; but one of them certainly, is in a thickly settled portion of the city. The Manhattan Works, as everyone knows, is in a very densely settled part of the town; so is the old works of the New York City Company.

Q. You mentioned that, in the gas delivered by the oxide of iron process of purification, there was remaining the element of sulphur, the same having been imperfectly extracted?

A. I stated that the iron process failed to remove sulphur to the same complete extent, to which the dry lime process removed it; but there is some remaining—a portion of what is not called the free sulphur—which would not have been there, if the other process had been adopted; that, I beg to say, is entirely independent of any chemical combination in the gas, and makes its appearance only when the gas is burned.

Q. That is not developed until combustion takes place?

A. No, sir; the other is that which is in a state of such chemical combination, that it gives to the gas manufactured, an ocular evidence of its presence by staining the paper.

189 A. Can that be discovered by testing it with lead paper in a dwelling house as it comes from the pipes?

A. If the gas is imperfectly purified.

Q. What, if any other defects, are there incidental to the oxide of iron process of purification—state them if you please?

A. I can conceive a greater objection to the iron process, than the small residue of sulphur which is left, is to be found in the carbonic acid, which the iron fails to remove from the gas; it is well known to all who are

familiar with gas, that the presence of this small proportion of carbonic acid, greatly reduces the illuminating power of the gas; and that it also, in a corresponding degree, diminishes the temperature of its combustion; I consider this great defect, for two reasons, that in the first place, it is the bounden duty of all gas companies to render to the community the best possible illuminator, and they fail in their duty when they fail to do this; second, the presence of the carbonic acid alluded to involves another danger, namely, the imperfect combustion of the gas, with more or less acetylene and carbonic oxide, or oxide of carbon; the carbonic oxide is one of the most poisonous of gases—far more so, one hundred times more so, Dumas says, than carbonic acid, which is commonly reputed a poisonous gas. 190 191

Q. Where the oxide of iron fails as a purifier, in this regard, the lime process succeeds?

A. The lime process is perfectly successful in the removal of the whole of the carbonic acid; and if it fails to do so in any case, it is simply from a slovenly application of the method; I can conceive that this feature of the iron process is its essentially weak point. 192

Q. Would you, as an expert, and chemist, advise the Metropolitan Gas Light Company to do away with the lime process of purification, and adopt, in preference to it, the oxide of iron purification for any reason?

A. I could not say; I should like to add a qualification to that: provided the Metropolitan Company take all needful and proper precautions to avoid the just causes of offence and complaint which exist against the lime process when not carefully conducted. 193

Q. You have ventured that modification in your answer, and I, therefore, will ask the question of you, what improvements could you suggest to the Metropolitan Gas Light Company, in the way of the manufacture and purification of gas?

A. Granting that the surface area of their lime purifiers is adequate to their daily production of gas—which is a point about which I am not fully satisfied—the one

- 194 important thing needful for them to do to avoid all just causes of complaint, is, in my judgment, that they should adopt a system of ventilation by atmospheric air, drawn by an exhauster through a box containing the spent lime after its cover has been raised, so that the atmosphere may have access, and before the process of oxydation—previously described at our last session—has set in, and the conveyance of the contaminated atmosphere drawn by the exhauster to another set of lime boxes charged with ventilated lime, which lime has been
- 195 found, by a frequent experiment—a constant daily experiment at the Manhattan Works—adequate to the complete absorption of all the offensive odors which are otherwise exhaled into the atmosphere; this process, properly conducted, leaves the lime in the exhausted box, in a condition of sulphate, or sulphite of lime and carbonate of lime—with a portion of unexhausted hydrate of lime, which is always present to a noticeable extent; this mixture is completely inoffensive; and may be left exposed to the atmosphere without
- 196 annoyance to anyone, and constitutes a valuable fertilizer which may be safely applied at once, in the business of agriculture; whereas, as is well known, the ordinary spent lime of gas works requires a long process of exposure, in order that it may not be rather injurious than beneficial to the farmer.

Q. What is the quality of coal that the Metropolitan Gas Light Company uses in the manufacture of gas?

- A. I made particular inquiry last week, when at the works, with reference to this matter, and I found in their
- 197 sheds the best qualities of bituminous coals. They were using, at that time, as their stock coal, the Westmoreland of Pennsylvania, which the best manufacturers of gas are pretty well agreed is one of the best coals accessible to the Atlantic border. They use, also, the Boghead cannel, which is universally esteemed as the richest of all the enriching coals. They had, also, the Lesmahago cannel, which stands next in commercial value and in illuminating power, to the Boghead.

They had, also, several other of the more esteemed varieties of the European cannel coals, but as I understand from Mr. White, the chief engineer, they were depending chiefly for the enriching of the quality of the gas, upon a mixture of Lesmahago and Boghead. I failed to mention by name one of the other coals which should be mentioned particularly, as it is in constant use there—the well-known Wigan cannel. 198

Q. What length of time would it take for the purpose of making those improvements, that you suggest, for the ventilation of lime? 199

A. Those improvements would require the construction of another house to contain the oxidating boxes; and its construction with the necessary underground works for the exhausters, I should think would require two or three months. That question, I should think, is one which would be better answered by the engineer of the company; for the conditions under which the work can be done, may require that it be done in the summer—that is, it may not be possible to do it while the ground is frozen. 200

Q. Do you know B. Howard Rand, Professor of Chemistry in the Philadelphia College of Medicine, and lecturer upon chemistry in the Franklin Institute?

A. Yes, sir—he is well known; I am not certain as to his being in that institution.

Q. What is his reputation as a writer and lecturer on chemistry?

A. He is a good chemical authority.

Q. I have before me an answer of Mr. Rand's, in these words: 201

“I do not believe that the odors arising from the refuse water and the other residuary products of gas manufacture, are, or may be injurious to health when the dry lime is used in the purifiers and is then exposed to the air and light. Sulphuretted hydrogen or hydro-sulphuric acid gas is disengaged. When the well containing ammoniacal liquor is allowed to remain uncovered, ammonia and hydro-sulphate of ammonia are given

202 off. That these gases, however, although offensive to most persons, cannot be considered as causes of disease or injurious to health, when freely diluted, is shown by the fact that the men engaged in removing night-soil as a nightly occupation, do not suffer in health, although exposed to these very gases in a far more concentrated condition than they can exist from the causes already named, and mixed with organic emanations of an equally offensive nature, which would certainly aid the injurious effect of these gases, did any such exist."

203 Do you agree with Professor Rand?

A. I do in the main. I might not agree with the exact transformation he speaks of, but in regard to the sanitary effect, I have expressed myself to that effect in the testimony given last week. I wish to say in this connection, that I do not think the permitting of the escape of those effete products, in densely peopled regions, is not a just cause of complaint, as an offense against the nostrils of the community. This is quite another question.

204 Q. I am speaking of the matter as to their deleteriousness to health?

A. I do not consider them deleterious to health—they may be annoying to comfort.

Q. As to the truthfulness of any charges which are made in regard to the emanations from the Metropolitan Gas Company, as being injurious to the health of the neighborhood—and especially to young persons and such—is there any foundation for such charges?

205 A. I do not believe there is any just ground for such charges.

Q. You have seen nothing to justify them?

A. I have seen nothing to justify that allegation.

Cross-examined by Mr. Hastings, counsel for the Board of Health:

Q. You stated, in your direct examination, that you had been practically familiar with the manufacture and

purification of gas for about twenty years, and had 206
studied the subject of its purification, both theoretically
and practically—please state what processes of purification
you have studied practically?

A. My practical experience with the purification of
gas has been chiefly with the dry lime, but I have also
had some familiarity with the wet lime purification, and
I have inspected the iron process.

Q. Did you ever study Laming's process practically?

A. No, sir; Laming's process has been brought into
general use since I was in Europe, and I have not had 207
an opportunity to examine it practically—meaning by
that, studying it in the gas works; I have been familiar
with Laming's process as a student in the science of gas
purification.

Q. Did you ever study the iron ore process, as used
in England, practically?

A. No, not practically in the works.

Q. Have you a practical knowledge of any iron process?

A. Not of my own experience. 208

Q. Then your practical knowledge is confined to the
lime process?

A. My practical experience—personal experience,
as an administrator of gas works; so far as I am advised,
there is but one, possibly two works, in this country
where the iron process is in use; one of these, and the
most important, I have examined, but not in the proper
sense of the word, practically, as I have not abided
there for the purpose of studying it, day by day, as I 209
should do if I was in charge of the works.

Q. If not acquainted with the iron process, do you
consider yourself fully competent to advise with regard
to its use?

A. I do; I do not conceive it is necessary for me to
have spent months in the gas works in order to reach a
safe and trusty judgment; the processes involved in
it are perfectly plain and obvious to any chemist; the
objections which exist against it I have already stated;

- 210 and they are such as must meet the assent of every chemist ; they are inherent in the very nature of the process. It is a most excellent process up to a certain point, but it fails beyond that point. The English companies have been compelled by law into its adoption ; but I know from my reading and familiarity with gas engineers and gas literature, that they would gladly return to the lime process, if it were practicable for them to do so, in densely peopled centres like London ; but that there are
- 211 practical difficulties attending the use of the lime process there, every gas engineer is free to admit ; practical difficulties growing out especially of getting rid of the waste. The iron process offers the gas companies the important advantage of economy in the administration of their affairs, in that they have not the daily recurring expense of purchasing new quantities of lime, and disposing of it, and, perhaps, at a loss ; for when they have once got their stock of iron on hand, it is revived by the oxygen of the air and the chemical transformation, as
- 212 already explained ; and the expense is therefore reduced to the manual labor of handling the material ?

Q. This is an advantage to the companies, but it is not necessarily an advantage to the community. What are the practical difficulties in its use, that you refer to ?

A. Of the iron process ?

Q. Yes, sir.

A. I have already stated those in my direct testimony, as being, especially the failure of the iron process to remove the carbonic acid.

- 213 Q. Give us the outlines, if you please ?

A. That it fails to remove, as perfectly as lime does, the sulphur ; and that in leaving a considerable portion of the carbonic acid in the gas, it not only abases the illuminating power, but reduces the temperature of the combustion, involving the risk of production of carbonic oxide and acetylene.

Q. As a general rule, does not a practical acquaintance with any process tend to correct or modify views you may have formed in advance of its adoption ?

A. I entered on the study of the iron question without 214
the slightest prejudice in its favor or against it. It is,
undoubtedly, true that a practical familiarity with any
process may tend to remove objections which are not
well founded, but it cannot remove objections which are
real and inherent, and in the nature of things. Nothing
can alter the properties of carbonic acid.

Q. Not having tested the iron process in its various
combinations, are you able to state that the objections
you name are well founded?

A. On general principles, yes, sir. I agree perfectly, 215
that if the lime process is made supplementary to the
iron process to such an extent as that the carbonic acid
shall be absorbed by lime, then the good effects of the
two processes may be combined; but that is attended by
another and very serious objection of a practical nature,
irrespective of expense, and that objection is, that the
gas suffers a needless loss of its illuminating power. It
is a perfectly well accepted principle among gas engi-
neers, that over-purification is a fatal error in the manu-
facture of gas. It is perfectly well known to chemists 216
who are familiar with this subject, that the illuminating
power of gas lies within exceedingly narrow limits, and
that the volatile hydro-carbons which are held in a gase-
ous state in an elastic form in gas, belonging to the ole-
fiant-gas series, are very easily removed from gas by over
purification.

Q. In your statement, that over-purification is a fatal
error, you restrict it to the illuminating properties of the
gas?

A. Yes, sir, certainly—the illuminating properties of 217
the gas. It is very well agreed now among gas engi-
neers, that that error has consisted to a too great extent
in the scrubbing of the gas with the water, that the
prolonged contact of gas with water in scrubbing, has
had the effect to remove too much of the illuminat-
ing power; and the purification process has been se-
riously modified by the best gas engineers, in the recent
times, in the omission, to a certain extent, of the scrubbing

218 Q. Does not the scrubbing process tend to remove the offensiveness of the gas?

A. Undoubtedly, but it may be carried too far, as already indicated.

Q. Too far with reference to the illuminating power?

A. Not merely that. It may be carried so far as to remove all the free ammonia, and in that case the gas has not present in it a trace of ammonia to combine with the sulphurous acid formed by the combustion of the sulphur compounds with the production of sulphite, and sulphate of ammonia in place of sulphurous acid.

219 Q. When and where have you seen green vitriol used in connection with the milk of lime you refer to?

A. I should like to suggest a modification of your question, because I did not state that it was connected with green vitriol, for that would be preposterous. I said the two things are used in succession.

Q. You did not mean to state that you have ever known green vitriol to be used in connection with milk of lime?

220 A. Not in the same vessel. This process is in use in Boston, and has been there used, to my knowledge, for 25 years. Since I had the pleasure of meeting you last, I have had an interview with Mr. Greenough, President of the Boston Gas Works, who informs me that they still employ the wet lime process, which process involves, as an essential feature, the partial use of green vitriol—in a distinct vessel, of course. The same process is in use in Providence.

221 Q. The iron process?

A. No, sir.

Q. The wet lime and green vitriol?

A. Yes, sir.

Q. Is not that an iron process?

A. No, sir, not in the sense that gas engineers use it. In the one case you will use sesqui oxide of iron and in the other protoxide of iron. In the one case you remove the ammonia—in the other not.

Q. Then the gas works in Boston and Providence do

not use a different process from that employed by the Metropolitan Gas Company ? 222

A. Yes, sir ; I so stated in my direct testimony ; I believe there are other works in New England that do the same, but those are the only ones I have a personal knowledge of.

Q. Where is the wet lime process now used in the United States ?

A. The places I have just mentioned, to say of my own knowledge.

Q. What is the difference between Laming's process and the iron ore process employed in Europe ? 223

A. In Laming's process there was a mixture of lime and sulphate of iron, with a view to the removal of the ammonia and carbonic acid. The iron ore process, as it is employed on the continent of Europe, I have never seen personally, but as I understand from those who have, it involves the use of the ore of iron—limonite—crushed and reduced to a proper state of powder, and mingled with some inert substance like saw-dust, spent tan bark, or some other inert substance. 224

Q. Can you state how Laming's mixture is made ?

A. I have never witnessed the preparation of Laming's mixture.

Q. What are the processes generally used in Great Britain or the continent ?

A. I think I have already stated in the direct examination that, in London, and on the continent of Europe, the usual process employed, is the iron process, that is a point admitted fully I think.

Q. Why has this process been employed instead of the lime process formerly in use ? 225

A. Chiefly from municipal regulations.

Q. What other reasons influence its employment ?

A. I think the cause which has been most influential, perhaps, with the companies, has been the consideration of economy, on their part. The restrictions in Great Britain, particularly with regard to the illuminating

- 226 power had been so very low, admitting the use of 12 to 13 candle gas, that it did not signify if there was a certain quantity of carbonic acid left in the gas, inasmuch as I have already explained in a former answer, the cost of the iron process is chiefly in the purchasing and maintenance of the stock, which is but very slowly exhausted and reduced, and is mainly due to the item of manual labor in the manipulation. There is an obvious economy on the part of the companies in their general expenses of administration, in the use of the iron process.
- 227 They have not to purchase, daily, new quantities of lime, nor to haul away the refuse. It is objected with great force by Mr. Clegg and others, to the use of the iron process, that its ventilation by the system known as Palmer's system, is impracticable, because of the destruction of the apparatus, incidental to the high heat produced by the oxidation of the iron, which is sufficient even to rise the mass to redness.

Q. That objection would apply only to wooden apparatus?

- 228 A. Yes, sir—I can conceive so; if temperature rises to redness it would undoubtedly endanger the purifying boxes, and would agglutinate the material so as to require some more mechanical treatment than the shoveling to reduce it to a condition fit for use.

Q. Has not the question of offensiveness influenced the change from the lime process to the iron process?

- A. Unquestionably, that has been undoubtedly the principal or efficient cause that has induced legislation on the part of Parliament and municipal regulations, the offensiveness of the lime process; it is offensive, that is what we are all ready to admit.
- 229

Q. In your reference to municipal regulations, what may we understand you to mean?

A. I understand that in Europe the police or local magistracy may present a gas company as a nuisance, if they judge, in their opinion, that the case is worthy of it; and that is what I mean by municipal regulations, as it is distinct from the general Metropolitan Gas Act, or

Parliamentary Act, under which the general administration of gas companies is placed. 230

Q. You would recognize then three different processes in present use—the dry lime, Laming's and the iron process?

A. I recognize four.

Q. The wet lime, also, I suppose?

A. The dry lime, wet lime, Laming's process and the iron process; there are essentially two, however—the lime process and the iron process; the others are modifications. 231

Q. You stated as an objection to the dry lime process that the accumulation of the effete waste product about the gas works, as ordinarily conducted, constitutes a just ground of complaint as a nuisance. Do you mean to limit this term nuisance to offensiveness of smell?

A. I do; and I mean also to limit that remark to the lime which is of comparatively recent origin, because in the accumulations about gas works, where large masses of effete lime are piled up, it is only a comparatively small portion which is offensive; the same effect takes place in a few weeks by the natural process of atmospheric oxidation, which, by ventilation, may be made to take place in two or three hours. 232

Q. Why, in large gas works would not this effete lime be exposed every few hours? The ventilators are opened about once a day, as I understand, in the winter season?

A. I do not know that I understand what you mean by ventilators. 233

Q. The purifying boxes, I should say.

A. The purifying boxes are opened at least once in twenty-four hours, ordinarily once in twenty-four to forty hours; but when the purifying boxes are opened for the purpose of ventilation there is no offence, because the act of ventilation commences instantly with the opening, and a current of air is then drawn inward to the products, so as to conduct them towards the other lime box where the offensive gases are secured.

234 Q. As a general rule, does not the introduction of any foreign element into the common atmosphere tend to taint and deteriorate it?

A. That is a general question, is it?

Q. Yes, sir.

A. Certainly.

Q. Will you state, in the order of their predominance, the constituents of the foul gas lime?

A. I don't know that I should be able to do so with accuracy from memory, as it is a pretty complex mixture; but I would mention the sulphide of calcium, and the sulphide of ammonium, and the carbonate of lime, and the unexhausted hydrate of lime; various compounds containing cyanogen, naphthaline, sulphuretted hydrocarbons, gas tar, probably phenol, or other analogous compounds, carbonic disulphide. This last product is commonly esteemed one of constant presence in the effete products of gas distillation, but I have reason to believe that it is not so commonly present as is supposed, from my own experiments. This is a general statement of what I conceive to be the important constituents present in the effete lime, prior to oxidation, while the box is yet closed, before atmospheric oxidation sets in; this effects important atmospheric transformations not here considered.

236 Q. This carbonic disulphide is identical with bisulphide of carbon?

A. Yes, sir.

Q. What gases are evolved from this mixture when exposed to the action of the air?

237 A. The first effect of access of atmospheric air to this mixture is that of oxidation, accompanied by a considerable elevation of the temperature, and the transformation of the previously existing compounds into new states.

Q. Watery vapor is exhaled in considerable quantity, carrying with it sulphide of ammonium and free ammonia vapor of naphthaline and the vapors of various other hydro carbons?

A. I have answered this question in my direct examination, perhaps with sufficient fullness; I called attention, in my direct examination, to the important fact as touching the question at issue in this suit, that the vapors or exhalations, or gases, if you please, which are given off from the effete lime vary in the different stages of the progress of the oxidation or transformation; that the first and overpowering impression which is made in the incipency of this act of oxidation, is that of ammoniacal vapors, whether free ammonia or sulphide of ammonium completely abasing and overpowering all other impressions; that the naphthaline odor is also easily recognized, but that the peculiar disgusting, heavy persistent odors which give to the gas lime its abominable smell, do not make their appearance until a later stage of the process; and that these odors are often more distinctly perceived at a little distance from the works—I would rather say at a considerable distance from the works—than near at hand, while on the other hand the ammonical odors, and the other odors connected with the ammonia disappear at no very considerable distance; in evidence of this I called the attention of the Board, at the last interview, to some test paper which had been exposed to the action of the atmosphere in the yard of the Metropolitan Gas Works, showing that the radius, measuring from the purifying house, upon which perceptible effects of sulphur vapors could be detected, did not exceed one hundred feet when the wind was blowing strongly in the direction of the paper from the purifying houses.

Q. Which, if any, of these gases are poisonous?

A. What do you mean by poisonous? Oxygen is poisonous.

Q. In the broad sense; not necessarily fatal to human life, but poisonous in tendency?

A. There is no gas which taken alone may not in the strict sense be esteemed a poison. An animal will die if immersed in pure oxygen, and quickly if immersed in pure nitrogen by suffocation, yet the two gases together constitute the beneficial atmosphere in which we live. An animal will die if immersed in am-

- 242 monia vapor, or in vapor of water, or in carbouic acid, either by direct suffocation or by specific poisonous influence. If by your question you intend to imply that either of the gases given off by the effete lime is exhaled in quantities sufficient to act as a poison, I take exception to the theory implied by the question, sulphide of ammonium is undoubtedly a poison, in that a small quantity of it comparatively will destroy life. The same is true of ammonia; the same is pre-eminently true of carbonic oxide. But these substances are often all present in the atmosphere, even of the purifying house in relatively very small proportions, and I appeal to the universal experience of the dry lime process of purification everywhere within my knowledge and reading, for the the absence of any evidence tending to show that any poisonous influence is exercised by these gases upon the health of persons frequenting those places and the places most exposed to them. I have yet to learn of the first instance of personal snffering, except in the single case mentioned last week, of the irritation of the eyes where persons were exposed to ammoniacal vapor, and that
- 244 was entirely transitory.

Q. When exposed to the air, what becomes of ammonia?

A. Free ammonia will speedily combine with carbonic acid in the atmosphere. Free carbonate of ammonia dissolves in the watery vapor of the atmosphere, and is diffused and lost—lost to the senses I mean—nothing is lost in a chemical sense.

- 245 Q. What gas will be liberated by the action of the carbonic acid of the air on the sulphide of calcium, after the ammonia has escaped?

A. I conceive, in the first place, that the carbonic acid of the atmosphere plays a very insignificant part in these chemical transformations. It is present only in 4 or 5 parts in 10,000 in the atmosphere. Undoubtedly the transformation which you ask about, would result in the decomposition of the sulphide of calcium, with the formation of calcic carbonate and the evolution of hydric sulphide.

Q. To what agent do you attribute the coloring of the lead test paper you exposed to the air outside of the purifying house? 246

A. Sulphide of ammonium. I do not conceive it possible that hydric sulphide as such should exist in an atmosphere abounding in free ammonia. The two substances will combine to form ammoniac sulphide.

Q. You regard Knapp's technology as good authority?

A. Up to the time of its publication, the publication in 1855, the second edition. 247

Q. In Vol. I., Part 2d, of the London edition of 1855, at page 610, he remarks as follows: "The mechanical retention of the ammonia is one of the chief causes of the intolerable stench which gas lime evolves when exposed to the air. Sulphuret of calcium evolves sulphuretted hydrogen slowly when decomposed by the carbonic acid of the atmosphere: but if ammonia be not present, part is composed of hyposulphite, which has no smell. In the latter case, however, carbonic acid is rapidly absorbed by the ammonia, and the neutral decomposition then ensues between the sulphuret of calcium and carbonate of ammonia, producing carbonate of lime and sulphide of ammonium, which escapes with its characteristic odor. So great is the nuisance produced by the effluvia from gas lime, that numerous plans have been at different times suggested for its prevention." Do you agree with his views, as there expressed? 248

A. The passage in question rests, as I conceive, upon a false hypothesis, viz: that it is the carbonic acid of the atmosphere which is the efficient and primary cause of the decomposition and chemical transformation of the effete lime. I cannot conceive that this theory is consistent with facts. The immediate and rapid elevation of the temperature which is perceived upon the exposure of the mass to the atmosphere, is to be accounted for, as I conceive, by no other hypothesis than that which is connected with the action of the atmospheric oxygen. It is an assertion which does not correspond with my own 249

250 observation and long familiarity with gas yards, that the peculiarly offensive smell of the gas lime is chiefly connected with the evolution of the ammoniacal products. I assume that the salts present in the mass, which are chiefly active in the primary oxidation and the evolution of ammonia, are the sulphide of ammonium and the sulphide of calcium, which may, if you please, be considered as united in a double sulphuretted salt. It is perfectly rational chemistry to assume that these salts react with a given number of atoms of atmospheric
 251 oxygen, with the evolution of free ammonia and the production of sulphite of lime, for example, or hyposulphite of lime, both of which are inoffensive substances. I differ with great diffidence and hesitation from so high an authority as Knapp's Technology, but it is a matter of chemical opinion, and one chemist has as much right to his opinion in such matters as another.

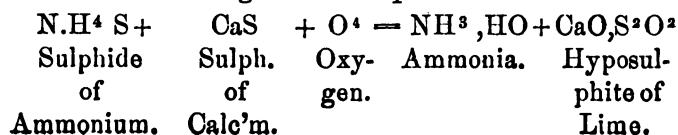
Q. Do you regard Samuel Clegg as a competent gas authority?

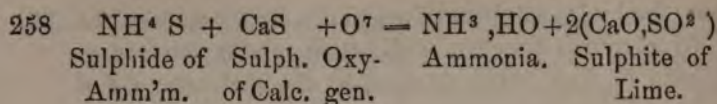
A. I do. He is one of the standard authors. The
 252 chemistry of Clegg's book is attributed to Frankland, who is certainly one of the best chemical authorities in gas matters.

Q. In his work on the manufacture of coal gas, fifth London edition, at page 187, he says, "Foul lime, as it is removed from the purifier, consists of an admixture of several salts. Those only that need to be practically considered are the carbonate and hydro-sulphate of lime and the hydro-sulphate of ammonia, which constitute an
 253 important part of the total bulk. The analysis of these principal compounds show that more than one half the mass consists of carbonate of lime, nearly one-quarter of hydro-sulphate of lime, about one-fifth is hydrate of lime unacted on, and the residue contains the cyanogen salts and the silicious and other impurities of the limestone, with the variable proportion of hydro-sulphate of ammonia retained in the mass mechanically. With such a mixture it is not surprising that the offensive odor is emitted on exposure to the atmosphere, for, in the first

place, the hydro-sulphate of ammonia must pass into the 254
 air by a simple process of diffusion, whilst the hydro-
 sulphate of lime being acted on by the carbonic acid of
 the atmosphere will give rise to the formation of car-
 bonate of lime, and a copious evolution of sulphuretted
 hydrogen gas. It is to the prevention of this evolution
 of sulphuretted hydrogen that the process of purification
 by oxide of iron owes its chief recommendation, for the
 affinity of oxide of iron for sulphuretted hydrogen is
 greater than for carbonic acid. Hence the sulphuret of
 iron, when removed from the purifiers and exposed to 2. 5
 the air, emits no odor, whilst the sulphuret of lime is re-
 adily decomposed, and produces an abominable smell.”
 To what extent, if any, do you differ from those
 views?

A. I am perfectly familiar with the passage which is
 quoted. Have often read it. Some of its positions I ac-
 cept, but in answer to the question would refer to the
 answer which has just been submitted to the next pre-
 vious question. Inasmuch as I take a fundamentally 256
 different view of the nature of the chemical transforma-
 tions, I consider the transformations due to atmospheric
 oxidation, and not to carbonic acid, and may be wrong
 in that opinion, but having embraced and entertained
 that opinion, after mature consideration, I shall adhere
 to it until drawn from it by experimental testimony? I
 have no partiality for one theory or hypothesis in this
 matter more than another, but seek to adopt that expla-
 nation of facts which is most rational, and consists best
 with all the phenomena concerned. I don't mean to be
 understood as excluding by any means the action of 257
 carbonic acid in such action, but I do not consider it the
 primary and leading action; on the contrary, as already
 repeatedly expressed, that the action has its origin in the
 atmospheric oxygen. In support of this opinion I would
 submit the following chemical equations:





Q. Subject to these modifications, you assent to his views, do you not?

A. Why no, I consider the two views irreconcilable, they are fundamentally different—totally different hypotheses; one commences with carbonic acid, and the other commences with atmospheric oxygen and carbonic acid; in other words, you have not the same factors, and you cannot have the same products; and, therefore, the two views are irreconcilable.

- 259 Q. In Dingler, vol. 125, page 159, taken from Dr. Ure, in speaking of the general malaria of London in 1850, in reference to the injurious influence of the gas lime on the health of the people, says, that "in building up a part of London named Pimlico, gas lime was used for filling up the swampy ground. During the month of October, 1849, five men descended into the sewer in Kenilworth street, for repairing, where they suddenly died. The corpses had a bronze-blue color, especially on the mouth, neck and heart. The sewer itself was 418 feet long, four feet high, and $2\frac{1}{2}$ feet wide; and was constructed out of bricks. The southern end of this canal was shut up on account of only three houses standing there; but the northern end communicated
- 260 with other sewers. There could only be drain waters entering the canal, as no other but those three houses had a communication with it. On the bottom of this sewer was found, on investigation, a greenish earthy material one foot in depth, covered with a similarly colored stinking fluid. A similar mass was found outside on the top of the canal. There was therefore, no doubt, but poisonous gases were generated from the gas lime. Ure, and several other chemists, analyzed the solid as well as the fluid contents of this canal, with the following results:

"The solid mass was recognized as gas lime saturated by hydro sulphuric acid, sulphide of ammonium, and cyanogen compounds. In contact with the carbonic acid of the atmospheric air, those obnoxious gases were liberated and absorbed by the rain water. This explains why the above mentioned green colored stinking fluid could contain those poisonous gases. 261

"From one of the London gas works spent lime was taken and washed out with water; the fluid was then analysed. One gallon of it contained 1,911 grains soluble matter, viz.: 1,330 grains lime, 301 grains ammonia, and 280 grains sulphur. One gallon treated with hydrochloric acid generated nearly three (3) gallons of dangerous gases, and $3\frac{1}{2}$ gallons of this fluid yielded 1 ounce of Prussian blue, which represents 25 ounces of hydrocyanic acid of the strength required by the London Pharmacopeia, a quantity sufficient to kill fifty persons. By this one may judge how detrimental to the health of the neighborhood the accumulation of gas lime must be." Do you consider the authority good? 262

A. Ure is good authority; I should infer from the reading of this evidence that these men had been killed by exhalations which undoubtedly had their origin in the gas lime under these exceptional conditions, and which contained hydrocyanic acid or prussic acid. The evidence, so far as stated, corresponds with that mode of poisoning. I would remark in this connection that the sulphocyanide of ammonium is a well recognized product of gas distillation; that it exists in all gas, probably; the illuminating gas I mean, as it is distributed to the houses; and it is the opinion of good gas chemists that it is the chief source of the sulphur which escapes in the combustion of the gas which has been otherwise purified from free sulphur. In this connection I would also say that the most thoroughly purified illuminating gas, it matters not by what method it may have been purified, is itself, in the sense which is here employed, a poison. An atmosphere containing a considerable portion of free illuminating gas would be destructive of 263

264 health, and that numerous cases are on record of life destroyed by persons who, having retired have carelessly blown out their light instead of extinguishing it. And though the atmosphere could not, in the course of time, intervening between the night and the morning, have contained more than ten per cent, at the outside, of its volume of these gases. That the offensive odor which illuminating gas retains is to be regarded as a blessing and not as a curse, that it is the one sufficient warning to instruct an unscientific and incautious person of the

265 existence of danger. That the suffocation of men who have descended into sewers or gaswells, is a fact of abundant record. Numerous instances have occurred in this country, some within my own personal knowledge, of men engaged in gas works descending into what is called the gas well to look after the attachments leading to the main distribution, having been suffocated and lost their lives, not in consequence of any specific poisonous property that attaches to the illuminating gas as such, but that they were drowned in the irrespirable

266 gases. They are irrespirable in the sense that they are insufficient of themselves, or even in the presence of atmospheric air, to sustain life, acting by exclusion of the atmospheric oxygen, and this is wholly irrespective of the question as to whether there may or may not be in the carburetted hydrogen gases portions of other substances, which are specifically poisonous in the sense that term is used by toxicologists.

Q. In the same sense, are not the gases evolved from spent lime when exposed to the air irrespirable?

267 A. They are clearly.

Q. In your opinion, is sulphuretted hydrogen decomposed in the air?

A. Yes, sir; decomposed or recombined; I would say, it may be decomposed or recombined with other substances in the air; sulphuretted hydrogen, or compounds of that gas with ammonia, are always present in the atmosphere of cities; a fact familiar to every housekeeper is that silver is speedily blackened by exposure to the

atmosphere of our houses in towns, which is attributable 268
to the presence of sulphur compounds in the atmosphere.

Q. Do you regard Berzelius as a standard authority
on the subject of gases ?

A. I do.

Q. In the fifth edition of his work, vol. 1, page 849,
Berzelius says that the sulphuretted hydrogen is not decomposed by dry oxygen ?

A. I did not say it was; I did not make any such assertion as that. You asked me if sulphuretted hydrogen 269
might not be decomposed in the air; I said yes; but the atmosphere is not dry oxygen.

Q. How do you suppose sulphuretted hydrogen to decompose in the air ?

A. There are various transformations of sulphuretted hydrogen in the air; it may be combined directly with ammonia or the carbonate of ammonia, both of which are liable to be present in the atmosphere from natural causes, in which case it would exist as sulphide of ammonium. 270
In the presence of watery vapor it may be transformed by oxidation; I wish to add to that another point, which is a fact familiar to every chemist, that the solution of sulphuretted hydrogen in water cannot be kept for any length of time because of the transformation or decomposition of that compound, accompanied by the precipitation of free sulphur, due to the combination of the hydrogen of the sulphur compound with the free oxygen dissolved in the water. The same transformation of sulpho hydric acid occurs in the atmosphere, and from the same cause, viz. : the oxidation of its hydrogen in moist 271
air.

Q. Is there much watery vapor in the atmosphere during the cold season ?

A. The atmosphere is never without watery vapor.

Q. Is there as much ?

A. There is less during the dry cold weather than during moist warm weather of course.

Q. Berzelius states, in the same volume, same page,

272 that a single cubic inch of sulphuretted hydrogen is sufficient to make its presence apparent in all parts of a room by a disagreeable odor. Do you doubt this?

A. Is the size of the room mentioned?

Q. In the case of a large room?

A. Terms are comparative; If by a large room he means a room of this size, I say yes; but if he means the Academy of Music, I say no.

Q. This sulphuretted hydrogen withstands decomposition for a certain length of time in the air?

273 A. Yes, sir; it is wafted upon the winds a certain distance from sulphur springs, but not to a very great distance. I spoke of these springs near Rome, and in the neighborhood of Avon and Sharon.

Q. Same vol., page 852, Berzelius says: "Thenard, referring to the poisonous character of sulphuretted hydrogen, remarks that a bird died in the air containing 1-1500th part of its volume of sulphuretted hydrogen, and a dog in air containing 1-800th part.") Do you agree with the statement?

274 A. Yes, sir; I do not admit the presence of free sulphuretted hydrogen in atmosphere containing ammonia. That is a point of difference between my friend Dr. Chandler and myself.

Q. Your statement as to the offensiveness of effete lime exposed to the air, would apply to the process as conducted by the Metropolitan Gas Works, would it not?

A. It would.

275 Q. Are you aware of any special precautions being employed at those works, to prevent the spent lime from becoming a nuisance or offensive?

A. Beyond the exercise of a reasonable vigilance, and cleanliness about their purifying house—in this respect I find the works in commendable order—I found no special precautions.

Q. There are none of the special precautions to which you refer?

A. No sir; there are not.

Q. Could not the Metropolitan Gas Company with 276
very little trouble or expense, abate, or effectually prevent this nuisance in the way described by you, or by some other method ?

A. The offence complained of in the case of the Metropolitan Company, may certainly be abated at no very large expenditure of time or money ; it will take some time, and take some money, and without new causes of offence, or new causes of unhealthiness. Certainly I should like to add to that answer, that in my judgment, they are entitled to a reasonable consideration in the 277
time requisite for the effect of such changes ; they of course, involve new constructions, and some expense.

Q. Is from the 15th July last, to the present time, a reasonable time to make the changes ?

A. If the changes in question had been contemplated in July, they certainly could have been effected by this time ; my familiarity with the case, however, dates from the 5th of February, I think. If they had entered upon such a process of reconstruction in July, they should had it in efficient action long ere this ; I cannot say, 278
however, of my own knowledge, that in the interim, they have not taken some precautions—that is more than I know.

Q. As an expert, you would recommend improvement in the ventilating process now employed there—would you not ?

A. They have none.

Q. Would you recommend the introduction of the ventilating process ?

A. I should recommend the introduction of a well considered plan of ventilation, as the only efficient cure for the evils complained of. 279

Q. You have recently visited the works ?

A. I have.

Q. Have you seen there any preparations for the introduction of such improvement ?

A. Not to my knowledge ; my attention was not called to any such ; the remark was made that they were about

280 moving certain masses of coal and buildings, with a view to new constructions.

Q. For what object?

A. I did not inquire; it appears that the Company have four extra purifiers—had at the commencement of this year.

Q. Could they not adopt the iron process in a much less period of time than that required for the ventilating improvement you mention?

281 A. They have two sets of four boxes each at the present time, two of the older and two of the newer form of construction. There is not room in their existing houses for the iron process. There is not sufficient space, as I conceive, for the display of the mass of effete iron for re-oxidation. It requires a very considerably enlarged area over the ordinary lime process to spread out the mass of spent iron, and revivify it. And that space does not exist in the present buildings. I should think the time consumed in suitable preparations for the iron process would not vary much from that which 282 would be required for ventilation. I said I thought three months ought to do it.

Q. Could not they introduce the oxide of iron there, so it should be used to purify the gas. Could they not in a very short time?

A. As I understand your question, it would contemplate the use of successive doses of iron material, as they now use successive doses of lime material.

Q. Could they not arrange to do that in a very short space of time?

283 A. I think that that course would be met with almost insurmountable difficulties, for this reason, that the iron process does not work so well the first action as in the second, third and fifth. It improves to a certain point in quality, and therefore you would always be at the worst point if you were always to renew it.

Q. Suppose they had proper facilities for revivification, would there be any difficulty in introducing the iron process at once?

A. None occur to me.

284

Q. What is the difficulty of using the space which they now occupy for their refuse lime for the purpose of revivification of their iron ?

A. I am not sufficiently familiar with the economy of the works exactly to say what the proper answer to that inquiry is.

Q. Is any peculiar machinery or buildings, or anything of that kind needed for revivification ?

A. Nothing but a shelter.

Q. A shed ?

285

A. Yes, sir ; you want a somewhat steady temperature. That is, you would not wish it exposed to the outer air,

Q. I believe nothing has been said of the kind of lime used by yourself.

A. In America we always use oyster shell lime.

Q. What is the advantage of oyster shell lime ?

A. It is an exceedingly fine form of lime. Its subdivisions or laminations render it peculiarly favorable.

Q. Is there any necessity of that shell lime being fresh ?

286

A. It must not have been carbonated ; it must be fresh hydrate of lime. Practically it is used as fast as it is burned.

Q. Is not the oyster shell lime used because it is cheaper ?

A. I don't think that is a primary consideration. No, it is not cheaper. For instance, in Portland it is not cheaper than stone lime.

287

Q. It is used in Portland ?

A. I can't say it is ; but I say in a lime country you can get stone lime cheaper.

Q. Where you can get stone lime, do they use stone lime or shell lime ?

A. I think that question would be decided by the relative economy.

Q. Are there not a great many portions of the world where they cannot get shell lime ?

288 A. In England they use stone lime almost exclusively.

Q. What period of time will 100 feet of gas in its consumption pass through an ordinary burner ?

A. It depends upon the size of the burner.

Q. Fix the size of the burner and fix the time ?

A. In a burner using 5 cubic feet of course it would be 20 hours.

Q. I want to know what is the ordinary burner used in the house, how much ?

289 A. Their name is legion, if you mean the volume of gas they consume.

Q. Yes, sir.

A. The volume of gas consumed would average from 4 to five feet.

Q. Therefore, it would take 20 hours on an average to burn 100 cubic feet of gas ?

A. Yes, sir.

290 Q. With 50 grains of sulphur in that 100 cubic feet of gas, it is your opinion that there is any injury to health from that amount of sulphur, in that amount of gas consumed ?

A. I never said there was any injury to health ; it is a nuisance ; the combustion in the house, of gas containing sulphur, occasions irritation to the eyes.

Q. Is the gas purified by dry lime ever free from naphthaline ?

291 A. I think that is dependent on the temperature at which gas is made, and the variety of the coal from which it is made ; gas that is made from poor coals is never free from naphthaline ; as you approach the limits of the law in England, in the matter of elimination, you increase the risk of precipitating the naphthaline which is held in solution in ordinary gas in virtue of the presence of the richer illuminating hydrocarbons ; hence, gas which is made from poor coals is always more likely to let fall its naphthaline, and to occasion trouble to the gas engineer, and to consumers, from the obstruction of the pipes by this crystalline

compound, especially in cold weather, than gas which is 292
made from rich coals.

Q. As the business of manufacturing gas in this city is conducted, is not naphthaline present ?

A. I conceive that naphthaline is almost uniformly present in coal gas, and that it is a very important constituent of coal gas ; it being a powerful illuminator, the objection to it being as I stated, that when from false views of economy, or other reasons, poor coal is employed, the naphthaline which ought to be sustained in the gas in the permanent form is precipitated, and the 293
loss of the naphthaline is a loss to the consumer.

Q. Is there any sanitary objection to its presence ?

A. I don't think there is ; it is rather an agreeable thing to me to smell naphthaline as a perfume.

Q. Is there probably more than a trace of phenol in gas as it reaches the purifier ?

A. I have never examined that question personally.

Q. What is your opinion ?

A. I certainly should not expect the presence of any large quantity of phenol in the gas, though there is 294
reason to believe it may be there is a sensible quantity.

Q. What becomes of the greater part of the phenol produced by the decomposition of coal ?

A. It is found in the coal tar, and associated also with the tarry portion of the lime, or other agents of purification, in the purifying boxes ; I brought to this room last week, but I am not quite certain that it was exhibited, a bottle containing lime richly charged with tar, from one of the purifying boxes of the Manhattan Company, in 295
proof that the tar is condensed in the purifiers, and Dr. Bowditch says you can always obtain from the best purified gas in London a portion of tar by methods which he gives, and I add that with the tar there is a legitimate portion of phenol ; phenol is the creosote of coal tar.

Q. What will become of the minute traces of phenol remaining in the gas after purification, after the gas is burned ?

296 A. I suppose it must be exhaled among the effete products of combustion ; I suppose it goes to watery vapor.

Q. Is it not quite probable that it will be burned with the gas ?

A. It is certainly possible.

Q. Is it not a good illuminating agent ?

A. It is.

Q. Is it probable that any possible nuisance could result from its presence, in ordinary practice ?

297 A. No.

Q. Have you any reason for believing the oxide of iron is less efficacious in removing the phenol than the dry lime ?

A. I have no experimental reason.

Q. Have you any other ?

A. I have an impression that the phenol would be more apt to rest with the lime than with the iron ; still that is an impression not founded upon the result of any experiments, and I do not attach any value to it.

298 Q. Is there any chemical reason supporting such an impression ?

A. It is rather hard to analyze one's convictions, or anything of that sort ; an impression rests in my mind, upon the general knowledge of the subject ; there is a compound of phenol with lime ; I don't know that there is any with iron ; there is just where the point of departure on the impression arises ; chemistry is an experimental science, pre-eminently, and experiment does not always substantiate the theoretical exceptions of chemists ; sometimes it does more.

299

Q. Is not this substance considered the best antiseptic found in gas manufactories ?

A. I so stated in my direct examination, and gave examples.

Q. And it is used in such practice ?

A. Yes, sir ; in the practice of antiseptics, and in the preservation of meats, and so on.

Q. Is it not probable that the carcasses you men-

tioned in your direct testimony as not likely to undergo 300
decay in the purifying houses would be preserved by
phenol, and not by sulphuretted hydrogen, and not by
sulphide of ammonium ?

A. I intended in that testimony to convey the distinct impression that it was the phenol that would act as the antiseptic generally, and never the sulphuretted hydrogen.

Q. Is there anything in phenol or its properties which renders the question whether more or less of it would pass by the lime or iron process of any import- 301
ance to this investigation ?

A. No ; I think not.

Q. Then the introduction of the question of phenol you would leave out entirely ?

A. I think it is a very interesting question, but I don't think the public health is prejudiced in the least by it.

Q. Is the phenol given out to the atmosphere from the effete lime, in any way so as to have a practicable or perceptible effect upon the atmosphere ? 302

A. The proper answer to that question would involve experimental data of which I am not possessed.

Q. You have no knowledge that it is so given out ?

A. No personal knowledge.

Q. Have you any theoretical knowledge ?

A. I think that in the decomposition of the lime it would be given out.

Q. So as to have any practicable or perceptible effect on the atmosphere ?

A. I revert to my testimony in regard to the effect 303
upon carcasses.

Adjourned to Thursday, the 18th instant, at one o'clock.

THURSDAY, FEB. 18, 1869.

Professor *Benjamin Silliman*, recalled. Examination resumed :

Q. Is not acetylene burned or destroyed in the combustion of the gas ?

304 A. Not always; on the contrary, acetylene is produced in the combustion of gas, if that combustion is in any considerable degree impaired. For example, in the ordinary wire gauze gas stoves, which are so frequently used in warming small apartments and in cooking, acetylene is produced in very notable quantities, as has been proved long since by Berthelot; and there is reason to believe that acetylene is also produced under other conditions than those of the wire gauze gas stove; when the supply of oxygen is imperfect, or from any reason, as
 305 from the presence of carbonic acid; perhaps it may be from an insufficient supply of oxygen gas. This fact has been very lately brought to our notice afresh by a recent memoir of Berthelot, which is published in the proceedings of the "Paris Chemical Society." The title is now changed to the "*Bulletin de la Societe Chimique*."

Q. As gas is ordinarily consumed, is acetylene produced in any considerable quantity?

A. The question is answered in a reply to your previous question. Berthelot, in the last memoir above referred to, affirms that in the ordinary bat'swing burner, as ordinarily used, acetylene may be detected. I have not verified this statement myself, but Berthelot is such
 306 an excellent authority that I would not question his accuracy.

Q. In Dingler, vol. 165, p. 149, Berthelot states that gas contains but a few ten-thousandths of acetylene. Do you agree with that statement?

A. How recent a number of Dingler is that?

Q. 1862. This is a copy of Berthelot's original
 307 article.

A. I accept whatever statement Berthelot makes, as an authority.

Q. Do you regard its removal from gas a matter of any importance in the quantity in which it generally exists?

A. I regard its presence in gas as very undesirable, and that whatever tends to its production should be carefully avoided, for I believe it is fully in proof that

the presence of small quantities of acetylene in the atmosphere where gas is burned, and resulting either from the distribution or combustion of gas, is proved to be particularly prejudicial to health and comfort, and that it induces headache, and sickness, and *malaise*, which is complained of by those who inhabit rooms which are warmed by unventilated gas stoves. It is one efficient cause of *malaise*. 308

Q. Do you regard it as any more injurious than the smell which arises from the burning of kerosene? 309

A. I am not aware that the smell which arises from the burning of kerosene is injurious. It is disagreeable and offensive. I never experienced any ill effect from these odors. Nobody of choice disseminates ill odors of any kind in apartments.

Q. Have you any good reason for supposing acetylene to be any more injurious than the odor just spoken of?

A. Yes, sir. I think that is clearly in proof that it is not merely an ill odor, but a poison acting on the nervous system. I do not know that any one asserts that the odor from burning petroleum is a poison.

Q. Your objection applies more particularly to cases where gas is applied to stoves? 310

A. The production of acetylene under those circumstances is far more notable, more abundant.

Q. Does it not appear in gas purified by lime as well as by iron?

A. I dare say it does; I have detected it in gas purified by lime.

Q. Have you not detected it in gas purified by iron? 311

A. I never have. I have never had the opportunity; I have never seen that process in operation, except at the New York Gas Works, and under circumstances not favorable to experiments. I simply consider it the duty of gas companies to render gas as free as possible from every source of objection that can properly be raised against it as an article of consumption in houses. It is unquestionable that in the United States we consume gas in our domestic life far more commonly than is done

312 in England. It is still a comparatively rare circumstance in England that gas is used in houses, and the prejudice against it in London when I was there, which was several years ago, was very strong, and chiefly, as I believe, because they had been so ill-treated by the metropolitan companies.

Q. Do you mean to state that the dry lime process is the only one which removes carbonic acid from the gas?

A. No; the wet lime process removes carbonic acid
313 very perfectly, and the Laming process may remove carbonic acid also, perfectly, if it is properly conducted; but I conceive that no iron process which is entirely without the presence of lime will purify gas completely of carbonic acid.

Q. Would not Laming's iron process, as applied in London, effectually remove the carbonic acid?

A. I judge from my readings only, for I have never had an opportunity of observing it personally, that Laming's process is capable, when properly conducted, of
314 depriving the gas of its carbonic acid, but that, in fact, as ordinarily conducted, it does not.

Q. I limited it to the London application.

A. I speak of it exclusively as applied in London. My inference is founded upon my readings of the discussions of that subject in the English journals. I know that the complaint is general in London of the low quality of the gas as respects illuminating power, and that the statement is constantly reiterated that the gas does
315 contain a notable portion of carbonic acid. It is true that the Metropolis Gas Act requires only 14 candle power, which we should consider very low.

Q. You stated that the oxide of iron of the New York Works evolved ammonia; where did it get this?

A. I do not recollect what I stated in my direct testimony; of course the ammonia must come from the gas.

Q. The oxide of iron does, then, absorb the ammonia from the gas.

A. It does.

316

Q. Is there any affinity between lime and ammonia ?

A. There is ; there is a double compound of lime and ammonia—the carbonate of lime and ammonia, a salt distinctly recognized. At the same time every chemist understands perfectly, that the action of quick-lime is to decompose ammonical salts and set ammonia at liberty, and it is for that express purpose that quick-lime and sal ammoniac are employed for the evolution of ammonia. In the ordinary dry-lime purification, the ammonia is of course in the largest measure removed by the water of the hydraulic main and the water of the scrubbers, and but a small portion of the whole product finds its way into the purifying boxes, and that chiefly as a sulphide of ammonium. I believe I have already explained that method of decomposition sufficiently—the ammonia and the effete lime.

317

Q. Has not iron a positive and well recognized affinity for ammonia ?

A. It has—the hydrous sesquioxide of iron, which is a common iron ore, is well known to absorb and retain it with obstinacy, and this property it possesses in common with ordinary clay, and it is to this joint effect that Liebig and other agricultural writers attribute the peculiar value and efficiency of clay in soils for the retention of ammoniacal salts.

318

Q. Has not iron a stronger affinity for ammonia than lime ?

A. Certainly.

Q. In your direct-examination, in stating the advantages of the lime process over the iron process, you gave as a reason that the lime more effectually removed the sulphur, carbonic acid, and ammonia ; what reason had you for embracing the ammonia ?

319

A. The ammonia is not removed in the lime process as ammonia ; it is not in that form that it occurs in the the lime purifying boxes ; it exists there solely as sulphuret of ammonium or ammoniac sulphide, and it is from the decomposition of this salt, under the conditions which I

320 have already described, that the powerful ammoniacal odor
 arises which is exhaled when the atmosphere commences
 its action upon the effete lime. I think I remarked in the
 same connection, as far as I can now recall my testimony,
 that I did not regard the presence of a small proportion—
 say not exceeding four or five grains of that substance in
 one hundred cubic feet of gas—as in any degree preju-
 dicial to the consumer ; but on the contrary that I thought
 its presence to a moderate extent—not exceeding that
 321 amount,—desirable, and that it was even desirable that
 there should be so much present that it would react upon
 turmeric paper, for the important reason that the presence
 of ammonia under these conditions secures the sulphur in
 a harmless form, since in the combustion of the sulphur
 the whole of that product appears as sulphurous acid ; if
 ammonia is also present at the same instant, the two sub-
 stances unite in the form of sulphite of ammonia, a salt
 which is white and harmless, and may be often seen con-
 densed upon the under side of the metallic bells that are
 322 hung above the chimney of an argand burner ; the coat-
 ing which lines the chimney, when it is moist and freshly
 made, and which may be seen afterwards when dry as a
 frosty looking deposit, is the salt of ammonia produced
 in the manner which I have indicated ; and hence
 I regard the presence of the small trace of am-
 monia which is usually found in gas, as rather beneficial
 than otherwise. The allegation that it produces nitric
 acid or nitrous acid in its combustion, appears to me to
 be of doubtful application ; at all events I have never
 323 seen the evidence of the presence of nitric acid under
 these circumstances.

Q. Then you do not regard its presence in gas as an
 objection to the iron process ?

A. Not at all—no, not to the extent specified ; it is of
 course quite possible for the gas manufacturer to send his
 gas to the consumer so imperfectly purified of ammonia,
 that its presence shall become a nuisance ; it is then
 altogether probable that nitric acid vapors will be pro-
 duced in a noticable quantity, and peculiar greenish, non

luminous character given to the color of the flame ; this 324
may be recognized by the eye. I have often observed
it as every careful observer must have done, in noticing
gas in the act of combustion.

Q. That inferiority would be more likely to exist in
gas purified by lime than that purified by iron, would it
not ?

A. I do not know that it would.

Q. Is it not true that the London gas purified by iron
is claimed to be remarkably free from ammonia ? 325

A. The parliamentary act—the gas act—allows the
presence of five grains of ammonia ; and I observed in a
recent discussion on the subject which took place within
the present month in London, that a distinguished gas
engineer, Mr. Hawksley, speaks of the presence of am-
monia as being easily recognized, by turmeric paper, in
the London gas. I do not remember of what particular
company he spoke. I have quoted Mr. Hawksley as
the authority. It occurs to me since doing so that it
might possibly have been one of the other gentlemen 326
who were involved in that discussion, which took place
on the occasion of Dr. Odling's lecture before the Board
of Health. In the *Journal of Gas-Lighting*, published
at London, July 7th, 1868, page 524, Dr. Odling says—
“the next constituent of coal gas to which I shall call
your attention is ammonia. The proportion of am-
monia in London gas is very small. We find that one
grain of ammonia in one hundred cubic feet of gas is
sufficient to effect turmeric paper, upon which ordinary
London gas is used, without, or almost without, action.” 327

Q. Would you regard Dr. Odling as authority upon
that question ?

A. I have quoted him as such. I was going to quote
him against himself. I have his lecture of the 2nd of
February, 1869, here.

Q. The gas referred to by him is purified by iron. Is
it not the ordinary London gas he speaks of ?

A. He does not say so, but I presume such is the fact.
With your permission I will read what Dr. Odling

328 says in his lecture before the Metropolitan Association of Medical Officers of Health, published in the "London Journal of Gas Lighting" for the 2nd of February, 1869,

Q. What does it refer to?

A. This question of ammonia.

Q. The presence of ammonia in gas?

A. Yes, sir. It is in support of what he says before:
 "I suppose I must say that all coal gas contains some ammonia—that is to say, it contains some, chemically speaking, so that if it were required to recognize it, ammonia might be detected in any coal gas whatsoever. The greater part of the coal gas supplied in London, however, contains but a very small portion of ammonia. The act of Parliament requires that coal gas shall be so free from ammonia as not to affect tumeric paper, and ordinarily the gas in London either does not or only just does affect turmeric paper. When we bear in mind the extreme delicacy of this test—I think it has been calculated that one grain of ammonia in 100 cubic feet of gas will affect the test paper decidedly—you may infer that the ammonia in ordinary gas, where it does not, or does only just affect the test paper, is so small as to allow of its being disregarded. At the same time where the ammonia does exist in any quantity, it is certainly objectionable. There is no doubt that by its combustion it produces a certain amount of nitric acid, which is prejudicial in many ways, and that the ammonia itself is prejudicial to the brass caps and fittings."

331 I believe that is the latest testimony we have on that subject. I would remark in that same connection, that I have lately determined the quantity of ammonia in gas, which I have been making, under a series of experiments, in connection with Professor Wurtz, in New Haven, with the hydrocarbon process, and I have found that it amounts to but little more than half of one grain in 100 cubic feet of gas, but that the gas which is furnished to the city of New Haven being made by a dif-

ferent process is considerably richer in ammonia, although still within the Parliamentary restriction. 332

Q. How much richer?

A. I cannot give you the figures until I calculate them: I have them in my pocket. I have not calculated the result.

Q. Does it color turmeric paper very distinctly?

A. Very decidedly—very distinctly. The other does not; it does not effect the turmeric paper at all. It falls within the observation of Dr. Odling that one grain of ammonia in one hundred cubic feet of gas will affect turmeric paper. 333

Q. Then it must contain more ammonia than the London gas?

A. I think it probably does, but I am not prepared to say that as of authority, for I have not the exact figures.

Q. I believe you have already stated, that the New Haven gas is purified by the dry-lime process?

A. Always.

Q. In the fifth edition of Clegg's "Treatise on Coal Gas," published in New York in 1868, page 196, he states:—"By none of the processes of purification we have described is bisulphide of carbon effectually removed; nor has any process yet been discovered by which gas can be purified on a large scale from this compound of sulphur. The metropolitan gas companies have consequently been unable to comply with the conditions required by the Metropolis Gas Act of 1860, that the gas shall not contain more than twenty grains of sulphur in every 100 cubic feet. The gas companies who supply the city of London applied to Mr. Barlow, in 1864, to ascertain whether it was practicable by any known process to abstract the sulphur compounds so as to attain the required standard of purity. Mr. Ellisen, the chemist of the experimental works of the Paris Gas Company, instituted numerous experiments with that object, but the conclusions they arrived at were not encouraging." Would you agree with Clegg in that statement? 334 335

- 336 A. Not entirely, for reasons that I would state; my own experiments upon the presence of bisulphide of carbon or carbonic disulphide in coal gas have not been such as to leave upon my mind the impression that this form of sulphur is of so frequent occurrence as is stated in nearly all literature on gas chemistry; I have diligently sought for that product by the best accredited methods in the case of the company of which I am the chemist, in New Haven; and in gas which I had especially made, by experimental processes, from various
- 337 sources, for myself, and I have not detected it; I do not mean to be understood to say that it does not occur, or occur frequently, in London gas; chemical testimony about that point is explicit; but I do mean to be understood as saying, that I do not regard it as by any means so frequent or of so universal occurrence as is stated; I believe at our last interview (as well as I recollect my testimony) that I made the statement which I now repeat, that there was, in my judgment, good reason to believe that the form in which sulphur more frequently exists
- 338 than in any coal gas, was that of sulpho-cyanide of ammonium—the combustion of course resulting in the production of sulphurous acid; I also stated, as I believe, in my direct testimony, that it was the current opinion of the best gas-engineers who have written upon this subject, as far as I know, that the lime process is more effectual in removing the sulphur than the iron process; and the evidence, as produced in the discussion before the British Association of Gas Manufacturers, which was
- 339 quoted on a former occasion, was adduced in support of that opinion; and that opinion I now reiterate, that it is not possible for the iron process so closely to remove the sulphur, as it is ordinarily conducted—I mean, as in the dry-lime process; if the dry-lime or other lime process is added as a supplement to or a portion of the iron process, then the sulphur will be as effectually removed in the one case as in the other.

Q. Dr. Letheby, in his quarterly report on the supply of gas in the city of London, given in the *London Jour-*

nal of Gas-Lighting, July 21st, 1868, page 562, states 340
that the average quantity of sulphur has not been excessive, though in 46 of 100 cases, the quantity of this impurity exceeded 20 grains per 100 cubic feet. The Great Central Company's gas averaged 14.54 grains, the Chartered Company's gas averaged 18.86, and the City Company's gas averaged 18.97 grains. Do you regard that statement as authoritative?

A. Of course—it is official.

Q. Do you regard the proportion given in that statement as excessive? 341

A. It falls, as an average, within the Parliamentary Act; in that sense it certainly is not excessive.

Q. The Companies referred to in this statement do not use the dry-lime process, do they?

A. I presume not; it is a point granted, that in London they use the iron process exclusively.

Q. Do you consider Professor William Odling, professor of practical chemistry, at Guy's Hospital, and Secretary of the London Chemical Society, an authority upon practical chemistry? 342

A. I have already had the pleasure of answering that question more than once, and I shall be happy to reiterate, as often as you repeat it.

Q. Have you read the following statement by that gentleman, on page 562 of the journal last cited, July 21st, 1868?

A. I presume I have. I read the article at the time of its appearance—the same being in his lecture to the British Association of Gas Managers:—

“So far then I am a little at issue with gas managers 343
in being disposed to admit, that ordinary coal gas contains a greater amount of sulphur in some form or other than they are willing to allow, and than the letter, though not the spirit of the act of parliament, permits; for the act was framed upon the results furnished by an incomplete combustion of the gas, and condensation of the products. But, on the other hand, I am altogether at issue with the public when they maintain that the

344 sulphur of gas produces, by its combustion, oil of vitrol
 or that the amount of sulphur ordinarily contained in
 gas is of any consequence whatever; and a little con-
 sideration will, I think, satisfy you of the soundness of
 this position. We will assume that coal gas contains, not
 20, but 40 grains of sulphur in 100 feet—a quantity at
 rate greatly exceeding the reality. Now, making the
 extravagant assumption, that the whole of these 40 grains
 of sulphur would be completely burnt—and in reality
 345 they would be burnt very incompletely—they would fur-
 nish by this combustion 80 grains of sulphurous acid
 gas. This quantity of the produced sulphurous acid
 would occupy, at ordinary temperature, about one-
 fifteenth part of a cubic foot, and since 100 cubic feet of
 our coal gas gives one fifteenth of a cubic foot of sul-
 phurous acid, 1,500 cubic feet of our coal gas would be
 required to furnish one cubic foot of the acid, even upon
 the extravagant assumption we have purposely made.
 But the combustion of 1,500 cubic feet of coal gas would
 346 produce something besides sulphurous acid. It would
 produce, at least, 1,000 cubic feet of carbonic acid, and
 in addition to its dilution by other gases and vapors, we
 should have our sulphurous acid diluted by 1,000 times
 its volume of carbonic acid. Now, if we can get at the
 proportion of carbonic acid in the atmosphere of a room
 highly illuminated with gas, and take the 1,000th part
 of that proportion, we shall be able to form some notion
 of the amount of sulphurous acid present. You will re-
 member that the amount of carbonic acid furnished by
 the breath of one individual is equal to that furnished
 347 by two or three feet gas burners, and that the maximum
 amount of carbonic acid found in the atmosphere of a
 crowded theatre was .32 per cent. Now, if in addition
 to our previous unreasonable supposition, we further
 suppose that an atmosphere contains .2 per cent. of car-
 bonic acid furnished by gas combustion, you will see
 that the whole matter becomes a *reductio ad absurdum*
 —that we might actually have one half millionth part of
 sulphurous acid present in the air of a gas-lighted room.

"But this sulphurous acid is not sulphuric acid, and 348
 can only be converted into sulphuric acid with very
 much pains and difficulty, as all who have tried the ex-
 periment of converting the sulphur of coal gas into sul-
 phuric acid are painfully aware. When gas is burned
 in special apparatus, indeed, its constituent sulphur can
 be converted into sulphuric acid, but it is very difficult
 to do this. The probability is, that of the sulphurous
 acid produced in ordinary combustion, scarcely a particle
 gets converted into sulphuric acid—certainly not more 349
 than the ammonia ordinarily existing in the atmosphere
 can neutralize, so as to form sulphate of ammonia instead
 of sulphuric acid."

A. Yes, sir; I am familiar with the statements alluded
 to.

Q. Is not sulphurous acid an excellent disinfectant?

A. No. I do not know that I should rank sulphurous
 acid as a disinfectant. I recognize it as an excellent
 antiseptic. There may be some confusion of terms in
 this regard. I regard chlorine as an excellent disinfec- 350
 tant, but I do not propose to fumigate my parlor with
 it.

Q. In the pamphlet on the application of disinfec-
 tants in arresting the spread of the cattle plague, by
 William Crookes, F.R.S., at page 20, is the following
 statement, entitled "Sulphur Fumigation":—

"Of all disinfecting processes this is perhaps the
 oldest. Its action was well known in the days of
 Homer, for we read that Ulysses employed it to remove
 the smell of dead bodies. It is recorded by Ovid, that
 the shepherds of Italy yearly purified their flocks and 351
 herds with burning sulphur, and passages in other
 writers show that they averted diseases from them by
 this means."

Would you agree with that statement?

A. I believe that sulphurous acid is a very powerful
 agent in destroying the germs and spores from which
 contagious and other diseases are propagated, and have
 so stated in my testimony already given.

352 Q. Is not an agent that removes infection, as you state, a disinfectant?

A. I suppose it would ordinarily be so classed, still the terms are used with a great deal of vagueness. Sulphurous acid is a well known specific agent for the cure of cutaneous diseases, a property which it enjoys in common with sulphur, from which it is produced, and for fumigation in hospitals, and for which purpose it is of long standing and with satisfactory results.

353 Q. Are you confident that the smell you perceived near the ceiling in the room where gas was burning—as described in your direct examination was sulphur.

A. I did not say it was sulphur; I said it was the smell of sulphurous acid and sulphite of ammonia, producing the well known choking effect which makes the stifling atmosphere observed in an ill ventilated room in which numerous gas lights are burning. I did not say it was sulphur—it is a very different thing.

354 Q. You stated that when the oxide of iron is ventilated in the purifiers it becomes heated and sets fire to the screens—is any difficulty of this kind experienced in the New York works?

A. In the New York works the iron is not ventilated in that manner. It is ventilated upon the floor. They do not ventilate the iron in boxes—the case is entirely distinct.

Q. Was there no necessity of ventilating the iron in the purifiers?

A. Not unless you wish to prevent a stink.

Q. What stink did you refer to in your answer?

355 A. That which is described as so noisome by some English authorities as exhaled from the effete iron.

Q. You never noticed that?

A. I referred specially for authority to the description of the Rev. Dr. Bowditch.

Q. You did not notice that offensive smell in your visit to the New York Gas Works?

A. No; my recollections in regard to the visit in question are a little indistinct, as I have stated in my direct

testimony. I remarked on that occasion, that I visited 356
the works for the purpose of examining into the economic character of the process, rather than its sanitary character, and paid but little attention to the stench.

Q. You are not aware that oxide of iron used in the gas works at Copenhagen is daily ventilated in these boxes?

A. I know nothing about the Copenhagen works.

Q. You stated that you visited the New York works last summer, among other things to ascertain the economic value of their process—what experiment did you 357
then and there make?

A. I made no experiments other than the ocular observation of the character of the gas which I noticed in the photometer rooms, or dark room in which I found it burning.

Q. How did you know then that the gas produced at these works was not as pure as when purified by lime?

A. I only inferred from the investigation of the gas, that it was a gas of low quality, and that as such it undoubtedly contained a portion of carbonic acid to which 358
its low illuminating power was attributed. It is well known that the presence of even a moderate quantity of carbonic acid very greatly depresses the illuminating power of gas.

Q. Could you detect the difference of one or two candles in the illuminating power of gas without the aid of the photometer?

A. Two candles very readily, unless the gas was of very high or low illuminating power; anywhere between the range of twelve and sixteen or twelve and eighteen 359
candles, I could detect with my eye the difference of two candle power readily. That is a matter of habit which grows upon one from constant use of the photometer, and daily personal observations with which I am familiar.

Q. In the German edition of Muspratt, vol. 3, at page 1522, is the following statement which I will ask Prof. Chandler to translate.

360 (Professor Chandler translated as follows :)

In speaking of the material used in purifying gas, Muspratt states that—

“Of all these materials, Laming’s mixture and the iron ore have obtained the most general or prominent introduction. Laming’s mixture has, above all others, particularly lime, essential advantages. After being once used it can be re-generated and used again. According to Unruh’s experiment in Madgeburg, the purification from sulphuretted hydrogen takes place so completely,
361 that one cannot detect the smallest trace by the most delicate re-agents, and the quantity of carbonic acid in the gas is extremely small—the illuminating power not less than when lime is employed ; and the smell of the foul mass trifling.”

Q. Do you regard that as good authority ?

A. I do not know the author of the article in question—whether it is attributed to Dr. Muspratt or to the German editor, Kerl. I only say that is a difference of opinion between many authorities, and that this state-
362 ment is at variance with the current literature of English engineers.

Q. From the same author and volume, page 1523, is the statement that Prof. Chandler will read, entitled, “Purification with iron ore :”—

“This ore is often cheaper or more easily obtained than Laming’s mixture, and is regenerated at first slower and afterwards more rapidly. At the new City gas works in Berlin, the ore obtained in Upper Silesia is employed. In the gas works of Hanover the fine pulver-
363 ized ore of Lunenburg mixed with spent tan and refuse dye wood is employed.”

Q. Do you regard that statement as authoritative ?

A. I regard it in the same light as the other statement by the same author ; it is an illustration of the difference of opinion that competent authorities entertain with regard to the same method.

Q. Do you recognize “Wagner’s Chemical Technology” as good authority ?

A. I do.

364

Q. At page 699 of that work it is stated that—" Much more important than all the previous methods of purification and really establishing an era, is the process of R. Laming in 1847.

Q. Do you regard Bloxam as good authority ?

A. He is a good chemist.

Q. In his chemistry, at page 450, referring to Laming's process, he says—" A great many other methods have been devised for the purification of gas from sulphuretted hydrogen, but none appear to be so efficacious and economical as that which consists in passing the gas over a mixture of sulphate of iron (green vitriol or cop-
peras) slacked lime and sawdust, which latter is employed to prevent the other materials from caking together. The lime decomposes the sulphate of iron, forming sulphate of lime and hydrated oxyd of iron." Would you agree with that statement ?

365

A. So far as I know, the statement is correct ; I mean, of course, in that answer that it is a correct statement of Laming's process, so far as I understand it ; I do not necessarily give in my adhesion to the inference which he draws from it.

366

Q. In Wagner's " Year's Book of Chemical Technology," vol. 9, page 713, it is stated in regard to the cheapness of the lime process. He simply states that the expense of purification is reduced to nothing by virtue of the value of the sulphur which is extracted from the foul oxyd. Have you any reason to doubt that statement ?

367

A. I have no reason to doubt the statement, though I have never seen that statement confirmed elsewhere ; it has often been mentioned as an advantage of the iron process, that the sulphur could be extracted from it.

Q. In Bowditch's work on the use of coal gas, London edition, 1867, at pages 19, 20 and 21, are the following statements :

" About this date the use of gas (that was in 1844, the

368 date referred to), the gas companies in London, and in some of the large towns, were sadly encumbered with and troubled about the lime refuse which arose from purifying their gas. Purified, the gas must be. Sanitary regulations most properly prevent the running of blue Billy—wet lime refuse—into streams and rivers, and in some cases prohibited the carting away from gas works, of dry lime refuse during the day time. Matters seemed to be approaching a crisis, when in 1840, Mr. Hills came to the rescue and introduced hydrous ses-
 369 quioxyd of iron as a purifying agent instead of lime.”

* * * * *

“When a certain quantity of sulphur has been set free in a mass of oxyd of iron it becomes useless—not because its chemical affinity for sulphuretted hydrogen is destroyed or even lessened, or because the ore has lost the power to restore it when it is foul, but because it is clogged with inert sulphur. Mr. Hills further showed that when thus useless as a purifying agent the
 370 oxyd yet had a value, for the accumulated sulphur could be converted into sulphuric acid, and for this purpose the oxyd was worth what it cost at first, and in some cases I believe even more. This was an enormous boon to urban gas companies. It delivered them from a great difficulty in reference to the foul lime, and taught them how to free their gas from sulphuretted hydrogen, without any cost for material to do so.”

* * * * *

371 “The use of lime after the oxyd would remove the carbonic acid from gas, and need not produce any nuisance or involve more than nominal cost, as the lime might be fit for use for the removal of carbonic acid over and over again. The evolution of the sickening vapors emitted by foul oxyd need not be a serious annoyance, as the oxyd can be revived in the purifiers themselves, or in a building whence all effluvia can be carried through fires into the atmosphere, so as to be harmless.” Do you agree with the statement read?

A. I accept Mr. Bowditch's statement of the iron

process as an exhibit of its claims, but I observe that he 372
recognizes the noisome exhalations which the iron gives
forth, and suggests a method for their removal which is
essentially the same thing which has been recommended
already for removing the similar nuisance from lime—a
method of ventilation which was tried here in the Man-
hattan Company, and blew up the chimney which they
built for the purpose, and destroyed considerable pro-
perty.

Q. In the "Manual of Elementary Chemistry," by 373
George Fownes, late Professor of Practical Chemistry in
University College, London—the London edition of
1868, edited by H. Bence Jones and Henry Watts, at
page 180, he says—"The use of lime, however, has been
almost superseded by that of a mixture of sawdust and
iron oxyd." Do you agree with that statement?

A. I do; that is a historical statement of the condi-
tion of the art in Great Britain and Europe.

Q. Do you recognize Professor E. D. Mapother, M.
D., as a good authority upon sanitary science?

A. Yes.

Q. In his lecture upon public health, Dublin edition 374
of 1867, at pages 53, 54 and 55, are the following state-
ments—"In both the gas works the mode of purifica-
tion had been by the wet lime process, and the result-
ing refuse was conveyed into open tanks for the pur-
pose of allowing the undissolved lime to settle from it.
This lime was afterwards used as luting for the retorts,
and the water is pumped under the furnaces, where it
is consumed. At the open part of the sewer in Ben-
son street, which has been recently covered in, about 375
thirty yards from where the boy was suffocated in July,
1864, this refuse water might have been often seen. I
believed that sulphurated hydrogen escaped from the
tanks while the refuse was exposed to the air, from the
luting of the retorts, and from the water while being
dried upon the furnace pans, and, I am convinced that
such escape was most injurious to the health of the
workmen and surrounding population. My opinion was

- 376 painfully verified by the suffocation of three men by sulphuretted hydrogen, in a pit dug on the premises of the Alliance works, in September, 1865. The lime refuse must have percolated from the tanks into the surrounding earth. Unwilling that so great, and in the beginning so expensive a change should be urged upon the companies, without my opinion being supported by London and other authorities, I wrote to the Medical Officers of Health of nine English districts. All condemned the lime process, and approved of the iron
- 377 process, except one eminent chemist, who stated that with proper precaution the wet lime process need not be a nuisance, injurious to health. I also consulted several eminent gas engineers, and quoted authorities such as "Muspratt's Chemistry," "Barlow's Chemistry of Gas-Lighting," "Hughes' Treatise on Gas Works," and thus produced much evidence upon the noxious character of the wet lime process in a populous town. In order to determine the matter by personal inquiry,
- 378 the corporation commissioned me to examine the works in London and other English towns, during October, 1860, and I accordingly visited the London, City of London, Phoenix, Equitable, Chartered, Imperial, York, and Scarboro' works, and ascertained that, in all the lime process had been found to produce nuisance, and that therefore, the oxide of iron process has been substituted. * * * * *
- 379 The only company which we now have, has entered into a contract for the erection of purifying chambers by the iron process, during summer, when alone extensive exchanges can be made in gas works, and they will be in action immediately."

Q. Do you accept these statements as authoritative?

A. I understand these statements as applicable in the instances cited about the wet lime process. I do not understand that the wet lime process is on trial here. Nobody proposes to introduce that. It is not used in more than two or three companies in the United States, as I have before stated; and it is, where the blue Billy

cannot be disposed of at once into the ocean, an unquestionable nuisance. 330

Q. Would not the fact that the authorities spoken of by this author introduced the iron process in preference to the dry lime process, go to show that they did not deem the dry lime process as furnishing the remedies?

A. They have been compelled by the municipal regulations to introduce the iron process into most of the towns of England. It is not from choice, but from necessity, as I understand, that this change has been effected in the majority of the cases. 331

Q. What authority have you for stating that the Metropolitan Company use Boghead coal in the manufacture of their gas?

A. I saw the coal there, and obtained a portion of the coal there for my own use.

Q. Was not that temporarily used.

A. I only mentioned Boghead as one of the enriching coals that they used.

Q. The inference might have been that they were in the habit of using "Boghead." 332

A. They used, I said, either "Boghead" or "Wigan," or "Lesmahago" or some other well accredited cannel coal. All those I saw there, and could speak of from my own knowledge. That is my authority—my own personal observation.

Q. Is your opinion that the gases evolved from refuse lime employed in the purification of gas are harmless, based upon actual knowledge of the effect of these gases upon the blood? 333

A. It is based upon an actual knowledge of the effect of these gases upon living men—human beings—in the vicinity of the gas works, and through a long course of observation. I have never made any experiments as to the effect of the introduction of this gas into the arterial or venous system of man. I believe my opinion of that subject was fully expressed on the occasion of our last interview in answer to a question which the learned counsel

384 to me, in respect to Dr. Ure's testimony in regard to parties being suffocated in a pit.

Q. You spoke of them as being drowned in the gases.

A. Yes, sir.

Q. How far from the gas may sulphide of ammonium be floated before it becomes so transformed as not to be perceptible to smell?

A. No very considerable distance.

385 Q. It would vary, I suppose, with the varying conditions of the atmosphere?

A. Compared with the distance to which the heavy and persistent odors of the hydro carbons are floated, to which just objection is made on the score of offence.

Re-direct examination by Judge Van Vorst :

Q. I would like to ask you whether the process called the Laming process is in use in the United States?

386 A. Not to my knowledge. The only gas works that to my knowledge certainly is employing an iron process is that one which has been so often mentioned in the City of New York, and they do not employ Laming's process, but a modification of the English or European iron process, in which, as already explained, a variety of bog ore or sesquioxide of iron is mingled with a certain proportion of iron turnings, the whole mass drenched with ammonia water, and mingled with charcoal and exposed to the atmosphere after oxydation, for the purpose of revivification.

387 Q. You know nothing about Laming's process except as you have read of it in gas literature?

A. I have never had the opportunity to study Laming's process, and know it only by reading.

Q. Do you know by reading whether it is adopted in Europe to any extent?

A. I believe it to be adopted to a considerable extent in some parts of Europe.

Q. In some parts of Europe, Professor Silliman, do

you know anything of what the advantages or disadvantages of it are, as compared with the dry lime process? 388

A. I believe I have already pretty fully stated my opinion upon that subject in the direct testimony, and also in the cross examination.

Q. Now, with regard to the wet lime process of which you have spoken—that you say is in use in Boston?

A. In Boston, and in use in Providence.

Q. Do you know whether it is in use in any other part of the country?

A. I do not know it to be in use elsewhere than in those two places. 389

Q. In your opinion the fouled lime, unless it may be removed by being cast into the ocean at once, is a decided nuisance?

A. It is a very decided cause of offence.

Q. How would it compare with the dry lime in that respect?

A. In that regard, it is more offensive than dry lime. It does not present the same opportunity for removal. This fouled lime must be removed in close vessels of some kind, or if suffered to remain in sewers or in streams, it would become a very just cause of offense. 390

Q. You stated that the ventilation of the oxide of iron in the boxes destroyed the boxes?

A. That is a statement which has been very frequently quoted in my direct testimony.

Q. If it could be ventilated in boxes, the noisome odors of which you have spoken might be avoided?

A. Undoubtedly, if a system of ventilation could be adopted which would prevent the too high temperature, I see no objections. 391

Q. You say there had been an experiment, as you understood—something toward ventilating it in the boxes—tried by the Manhattan Company with regard to the lime?

A. Yes, in the case of lime.

Q. Did they not attempt to ventilate the lime there in the boxes?

392 A. The case to which I alluded is this : They attempted to adopt substantially what is known as the Palmer process of ventilation, which consisted in expelling the air which had been drawn through from the boxes, carrying with it the offensive odors into the bottom of the stack or chimney provided for that purpose, with the expectation of burning it in that stack ; but the result was an explosion; resulting from the mingling of the gas and the atmospheric air , which destroyed the stack and blew the engineer out of the window, and damaged
393 property to a considerable extent.

Q. And subsequently to that they have made additional improvements ?

A. They have adopted an entirely different method of ventilation, which has already been explained in the previous testimony.

Q. Now, do you know whether that method of ventilation of the fouled lime adopted by the Manhattan Company of which you have spoken in terms of commendation
394 prevails anywhere else in the United States or in Europe ?

A. I am not aware that it has been adopted anywhere else in the mode it has been adopted there.

Q. Did you regard that, then, on the part of the Manhattan Company as an experiment ?

A. I regarded it as a successful experiment.

Q. But as an experiment nevertheless ?

A. It is an experiment of their own introduction. I do not regard it as an experiment if that implies a doubt of its success.

395 Q. Would you regard that as an improvement ?

A. Yes, sir.

Q. Do you know whether it is or is not the subject of a patent ?

A. I do not know anything about it.

Q. How late is it that that method of ventilation of the fouled lime in the Manhattan Company has been communicated to the public to your knowledge ?

A. It has been well understood among gas engineers and persons interested in gas-purification for more than

a year that the Manhattan Company had achieved a suc- 396
cess in that direction.

Q. But the details were not known?

A. I think not. So far as I know about this, there
has been no detailed description of the method or its op-
eration, as of authority.

Q. It has not made its way into the literature of the
art, as far as you know? It has not entered into the
gas-literature of the day?

A. It is not to be found, as far as I know, in any of
the gas-literature of the day; I think the description 397
we have given in this discussion here, was the first which
came before the public in a formal manner.

Q. When did you see it first yourself?

A. I first saw it some time during last summer, per-
haps it might have been in June.

Q. Then you first visited the works—first became ac-
quainted with the fact that they had this method?

A. I have been in the habit of visiting the Manhattan
Works for a great many years, but I visited them for a
knowledge of the new system of ventilation last sum- 398
mer; and more recently I have visited them again.

Q. At that time it was regarded by them as a suc-
cess?

A. Yes, sir. The engineer spoke of it to me as being
an experiment at the time.

Q. But subsequent experiences have proved it to be
measurably successful?

A. Yes, sir. They are so well satisfied with it, that
one of the officers told me last week, they contemplate 399
the coming season to erect new sheds to cover the neces-
sary revivifying boxes.

Q. They produce much more gas in the Manhattan
Company than they do in the Metropolitan Company?

A. I think four or five times as much.

Q. And use four or five times as much lime for puri-
fication?

A. Yes, sir.

Q. Whatever there is offensive about the manufac-

400 ture of gas—if there is anything offensive about effete lime—it would be magnified at the Manhattan Works?

A. Yes, sir. My recollection is that they consume one bushel of lime to every 3600 or 3700 cubic feet of gas, and that the daily make of gas is 5,000,000 cubic feet.

Q. The oxide of iron at the New York Works was you say, on the floor?

A. Yes.

Q. It was not ventilated in the boxes?

401 A. No, sir.

Q. And whatever was objectionable in regard to its emanations and exhalations went into the atmosphere?

A. Of course.

Q. Of whatever character?

A. Yes, sir.

Q. As you went there for the purpose of regarding the process in its economical bearing, you were sufficiently informed as to that?

A. No, sir.

402 Q. You have been inquired of by Col. Hastings, as to the article of William Odling, Professor of Chemistry at Guy's Hospital, and the article has been put into your hands for examination. Now, sir, will you please to state, in what regard, if any, you differ from Dr. Odling in regard to that method?

403 A. Dr. Odling has rehearsed with great detail the whole matter of the chemistry connected with the combustion of gas in houses, on the occasion of the recent meeting of the Metropolitan Association of Medical Officers of Health.

Q. How recent, Professor?

A. At a meeting of the Board of Health held in Fleet street, London, in January of this year, as I understand.

Q. Subsequent to the article (to which your attention has been called) of his, July, 1868?

A. That article was the substance of an address which he gave before the British Association of Gas Engineers. This is substantially the same as the former lecture, but

is somewhat more in detail, and it is in print, particularly the consideration of questions connected with the consumption of gas in houses relative to domestic use. With his customary clearness and exactness of statement, Dr. Odling in this very interesting communication, which extends over five columns of the *Gas-Light Journal*, goes minutely into the consideration of all the important questions raised by the subject of discussion, and, among others, he rehearses what has been before quoted with respect to the amount of sulphur which is contained in gas; and following this communication is a discussion on the points of the lecture, in which Dr. Letheby, Mr. Hawsley, Mr. Findlay, and others took part. Dr. Letheby, whose name is even more intimately associated with the subject of gas-chemistry than is that of Dr. Odling, and who is the gentleman to whom we are indebted for some of our most important methods of analysis in gas chemistry, takes exception to the remarks of Dr. Odling, in respect to the importance of the sulphur product resulting from the combustion of gas, meaning thereby, of course, the products of sulphurous and sulphuric acids, which are evolved in its combustion. With your permission, I will submit a few of Dr. Letheby's remarks in detail. In the *Journal of Gas-Lighting*, London, Feb. 2nd, 1869, page 83, he says: "And now I am desirous of making a few remarks on the effects of sulphur in coal gas. Dr. Odling has directed your attention to this matter from a statistical point of view, and has shown you how, by a mathematical process, the amount of sulphur acids in the products of burning gas may be reduced to a vanishing point, and that, therefore, they must be insignificant and wholly harmless; but I will ask you to look at the subject from another point of view, and to examine it in the light of facts, as well as of figures. About fifteen or twenty years ago, when I began to inquire into this matter, I was struck with a circumstance which is now, as it was then, very remarkable, namely, that wherever gas is burned continuously, and in large

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408 quantity, it causes a rapid destruction of textile fabrics,
 with a very acid condition of them. This is notably so in
 our public libraries, and in warehouses and shops. I
 obtained so many striking proofs of this, especially
 from the libraries of the Athenæum Club House, the
 London Institution, the College of Surgeons, and else-
 where, that I made them the subject of a special report
 to the city authorities in 1854, and here you will see
 the specimens of covers of books which were furnished
 to me at that time. If you apply a piece of the leather
 409 to your tongue you will taste its acidity, and if it be
 treated with water or spirit of wine, and tested with a
 solution of baryta, it will be found that the acid is sul-
 phuric acid. These effects were observed many years
 ago, in the library of the Athenæum Club House, and
 they were growing to be so serious that the managers
 requested a commission of chemists, including Doctor
 Prout, Mr. Aiker, and others, to inquire into it, and I
 have before me a copy of their report on the subject.
 It is to the effect that the mischief is clearly due to the
 presence of sulphuric acid, which had come from the
 410 burning gas; and they state that the mischief will con-
 tinue as long as gas is continued in the library without
 proper ventilation. Mr. Faraday thereupon designed the
 system of ventilation which is still used in the library.
 As to the effects of the products of burning gas on
 shop goods, they are notorious, for such goods are regu-
 larly disposed of as damaged or gassy goods. It has
 been remarked, too, that plants are quickly killed by
 the products of burning gas, for they are peculiarly
 411 susceptible of injury from the presence of sulphurous
 acid in the air; according to Drs. Christison and Far-
 mer, as little as one part in 10,000 of air will kill plants
 in less than 24 hours. And you cannot use gas in a
 conservatory, either for heating or for illuminating
 purposes, unless the products of combustion are entirely
 removed. Dr. Christison has written to me very
 strongly on this subject; and he attributed the absence
 of flowers and plants from the rooms of Edinburgh to

the circumstance that gas is universally used in them. 412
 Advancing a step further in my inquiries, I ascertained
 that the water produced by burning gas, collect it
 how you will, is always acid, and will rot leather,
 paper, cotton, and linen. Here are specimens of such
 tissues, which have been dipped in the condensed liquid
 products of gas combustion, and you will observe that
 they are as rotten as tinder. Lastly, I contrived a plan
 whereby the amount of sulphur in coal gas could be
 estimated. I had thought that the instrument was suf-
 ficiently well known, and the *rationale* of its action 413
 thoroughly understood; but the instrument which Dr.
 Odling has placed upon the table, and has described to
 you as my ingenious contrivance, is so different in all
 its essential particulars from my own instrument that
 I disown it, and call it an ingenious perversion of the
 apparatus which bears my name. I know from expe-
 rience that such an instrument will not discover half
 the sulphur that is really present in coal gas; and I
 have no doubt that the discrepancies which have lately
 been referred to by writers on this subject have been 414
 occasioned by the use of such an instrument as is now
 upon the table. The particulars of my instrument, the
 measurements of the several parts of it, and the mode
 of using it, are fully described in Mr. Sugg's book on
 Gas Manipulation, and if it be used in a proper manner
 it will discover all the sulphur of the gas; and thus it
 will be found that the amount of sulphur may reach to
 from 30 to 40 grains per 100 cubic feet of gas. If the
 presence of sulphur in such quantity in coal gas was an
 unavoidable necessity, and could not be reduced by any 415
 reasonable process of manufacture or purification, it
 would be folly to complain of it, other than to show the
 necessity for good ventilation where gas is burnt; but
 this is not the case, for there are processes of purifica-
 tion which will easily diminish the amount of sulphur
 to less than half the usual quantity. Mr. Hawsley,
 whose presence this evening will, I hope, be useful to
 us, by his giving us the results of his large experience

416 in this matter, has shewn that by copiously washing
 raw gas with ammoniacal liquor, it is possible to re-
 move a large proportion of the sulphur compounds of
 gas without injuring in the slightest degree the illumi-
 nating power. After this treatment the gas should be
 deprived of its sulphuretted hydrogen by means of
 hydrated oxide of iron, and then while a little ammo-
 nia is still remaining in it, it should be further purified
 by passing it through dry lime, which is the slightly
 417 moistened hydrate of lime. In this way the ammoniacal
 liquor is strengthened to a high degree—it being
 rarely less than of 10 oz. strength by the absorption
 of ammonia compounds, and by the removal of sulphur
 in other forms than that of sulphuretted hydrogen.
 The hydrated oxide of iron is also less foul than it
 usually is, and is capable of revivification, without
 annoyance, while the hydrate of lime is actually in-
 offensive, for it contains nothing but carbonic acid and
 sulphocyanogen and sulphur produced by the reaction
 of ammonia on bisulphide of carbon in the presence of
 418 caustic lime. Mr. Hawksley will tell you, what I also
 know from experience, that by these means the amount
 of sulphur in coal gas is easily and certainly reduced to
 about ten or twelve grains per 100 cubic feet of gas. It
 is easy, as I have said, to meet this question by a nu-
 merical argument, and to show by a mathematical pro-
 cess of reasoning that the amount of sulphur in gas may
 be made to vanish almost entirely ; but I would rather
 examine the practical or experimental fact, and endeavor
 419 to remedy what is among practical men an acknowl-
 edged evil, by applying those remedies which are clearly
 within our reach.”

In that connection I desire to present to your notice
 a quantity of sulphur by actual weight, such as the Eng-
 lish law allows, viz. : 20 grains of sulphur to each 100
 cubic feet of gas.

[A weighed portion of 20 grains of sulphur was here
 offered in evidence, and package marked “Exhibit B.”]

You will observe that it is by no means an insignifi-
 cant quantity, regarded as a material substance. I may

say, that if that quantity of sulphur were suddenly 420
 burned in an atmosphere no larger than that in an ordinary sitting room, the air of the room would be insupportable. But is worthy to be remembered that that quantity of sulphur is actually set at liberty in the form of sulphurous acid in about five hours' time in an evening, in a room which is lit by four ordinary gas burners of the capacity of five feet each, and that it is in evidence from Dr. Letheby and others, that the gas may even contain 30 or 40 grains in every 100 cubic feet. It is always to be remembered that the largest 421
 product in bulk which is given off in the burning of gas, is water in the form of watery vapor; and that this watery vapor takes up and absolutely retains sulphurous acid, and rests upon the windows, upon the paint, and upon the hangings, if there are any; and upon the books and bindings that are in the room, and that in the upper portions of the room it is especially noticeable, owing to the temperature, resulting from the combustion and the warmth of the room, that these products are most abundant.

In this connection Mr. Hawksley remarked, in the 422
 discussion before alluded to, that:

"He was enabled to state that by the use of ammoniacal liquors for the purpose of washing the gas and by the use of lime in the process of purification, the sulphur could be reduced without any sensible depreciation in illuminating power to as little as 10 grains in 100 feet, that was to say to as little as one-half the quantity which was allowed by act of Parliament. Now, it might be said that this was not worthy the attention 423
 of professional men in that room. It was said, and said with some truth that the gas companies had been driven away from the use of a very valuable agent, by persons who complained that the use of lime in the purification of gas was a nuisance. They had consequently been driven to employ the oxyd of iron, which was a very imperfect agent for the removal of some of the compounds; and the general result was, that in or-

424 der to free our streets from the occasional smell of foul
 lime, we put sulphur into our dwelling houses. He did
 not think it was any improvement in a social sense at
 all, and it was always desirable to ascertain whether,
 in effecting changes which might be proposed, and
 which might appear to be beneficial, we were not pro-
 ducing injurious effects in another direction. How-
 ever, such had been the results. He did not think
 with regard to the question of the presence of ammo-
 nia, that any notice whatever, in the present state of
 425 the manufacture of gas, need be taken of that agent.
 The quantity was so small, even in the gas which was
 the worst purified, in the sense of the removal of am-
 monia, that he did not believe any effect at all—any
 appreciable effect—detrimental or otherwise, would
 arise, and he would say this with regard to the alleged
 effect of gas upon books and furniture, and other arti-
 cles of that sort, that, although he believed there had
 been a considerable effect produced when gas was very
 much more purified than it was at the present day, yet
 426 he believed there were now other causes operating to
 produce the effect, which were at least as great as gas,
 if not greater. The quantity of coal consumed in Lon-
 don gave off more than 6,000 tons of sulphur into the
 atmosphere every year, and so large a quantity as that,
 must in itself produce a very sensible effect; in point of
 fact, we know it. But besides that, we must not forget
 the influence of temperature. With a large quantity
 of gas burnt in a room, near the ceiling, unless special
 means of ventilation were adopted, the temperature
 427 would be very high indeed—so high that it would be
 impossible to exist in it for many minutes, perhaps not
 for one. Well, now, that had a very serious effect upon
 books and furniture, and he attributed very much
 of the rottenness of books—always greater on the
 higher shelves than on the lower—to that cause. He
 believed gas had been very largely discredited in con-
 sequence of other influences, which did not proceed
 from the combustion of gas itself.”

* * * * *

"Mr. Findlay said he had been connected with two 428
of the largest gas companies in London for sixteen or
seventeen years, and he quite agreed with the remarks
of Mr. Hawksley about the use of lime. It was a ques-
tion whether they ought not to go back to the old prac-
tice. It was well known that there was no better pro-
cess of purification than by means of wet lime or dry
lime, it must always be a nuisance to a certain extent."

By Mr. Van Vorst :

I don't know whether it was taken down or not, but
I understood you to say in your cross-examination, 429
that gas in London was not consumed in the dwelling
houses to anything like the extent that it is consumed
in the dwelling houses in this country.

A. That was the case when I was familiar with
London; and it is not to this day, as I am assured, es-
teemed fashionable to hold a ball, or reception or enter-
tainment in the evening, with gas. The houses are
lit then with wax candles, and there is still a prejudice
in London, to a great extent, against the use of gas in
houses, to a much greater extent than is known in this 430
country.

Q. Is there anything more you wish to say ?

A. I think the subject has received sufficient ventila-
tion without trespassing on the time of the honorable
Referee any further.

By Mr. Hastings :

Q. Is not the quantity of sulphur left in the gas after
purification very largely caused by the kind of coal
employed in the manufacture of the gas ?

A. Not necessarily. The amount of sulphur com- 431
pounds produced is directly as the amount of sulphur
in the coal, but the amount of sulphur left in the gas
depends largely on the method of purification. If the
gas is improperly purified, of course the amount of
sulphur it contains would be greatly increased. The
difficulties and the cost of purification, and the time
which is consumed in the act of purification, are all
greatly increased by employing a coal which, in the,

432 technical language of the coal house, is dirty. Dirty gas is like to be the consequence. There are many coals which, 'but for the large amount of sulphur they contain, would be very desirable indeed, as gas coals, but they are inadmissible, from the reason referred to. This remark is true of most Nova Scotia coals, some of which will yield as high as $4\frac{1}{2}$ cubic feet of gas of excellent illuminating power, by reason of the large amount of sulphur which the coal contains, it is found not economical or profitable to employ it. I beg leave,

433 in this connection, as you have brought the subject up, to call your attention to an important paragraph in Clegg, which Mr. Chandler will at once remember. On page 197, he states in a single instance that "one of the anomalous results obtained in the experiments—alluding to experiments made by Mr. Palmer and Mr. Ellison, which you have already quoted—"that the quantity of sulphur present in the coal does not bear any proportion to the sulphurous compounds in the gas produced from it."

434 Q. Other things being equal, would not a coal containing 20 per cent. of sulphur, yield a gas containing more sulphur products than that produced from a coal containing 10 per cent.?

A. I conceive that the answer to that inquiry is properly conveyed in my former answer. The quantity of sulphur products would of course be in proportion to the amount of sulphur contained in the coal, but that which would remain in the gas would not be necessarily greater. In this paragraph which I have just

435 quoted is a single sentence perfectly in point: "Thus it appears that the gas obtained from the Denain coal, from the neighborhood of Valenciennes, which contains 31.10 pounds of sulphur in one ton, gave a maximum of 748 grains of sulphur per 100 cubic feet, while the gas from Stavely coal containing 26 pounds of sulphur in one ton, yielded 22 grains of sulphur to 100 cubic feet of gas." It appears, therefore, in answer to your question, that there is no direct ratio between the amount

of sulphur contained in the coal and that which will 436
be found in the gas—that the coal which contains a less
proportion of sulphur as an original constituent, than
another coal, may yield a gas which contains less
sulphur by constitution than the gas produced from an-
other coal containing a larger amount of sulphur.

Adjourned to Saturday, February 20, at one
o'clock.

BEFORE THE BOARD OF HEALTH.

437

IN THE MATTER

of

The application of OSCAR ZOLLIKOFFER, President of the Metropolitan Gas-Light Company; for the modification of the order No. 425, dated July 14th, 1868, of the Metropolitan Board of Health, concerning the business of Manufacturing Gas at the foot of West 42d Street, New York.

438

OFFICE OF THE METROPOLITAN BOARD OF HEALTH,
No. 301 Mott Street,
NEW YORK, February 20th, 1869.

CONTINUATION OF THE HEARING BEFORE S. C. HAWLEY,
REFEREE.

439

SATURDAY, February 20th, 1869.

Ex-Judge H. C. Van Vorst appeared for the Metropolitan Gas-Light Company.

J. S. Hastings appeared for the Board of Health.

Professor *Henry Wurtz*, called and sworn on behalf of the Metropolitan Gas-Light Company; examined by Judge Van Vorst:

440 Q. Where is your residence?

A. My residence is in New Jersey; my business in New York City.

Q. What is your vocation and profession?

A. I claim to be a chemist; call myself a scientific and practical chemical expert.

Q. How long have you studied the subject of chemistry?

A. About 20 years, sir, more or less.

441 Q. With what institutions have you been connected in the practice of your profession as a chemist?

A. I was at one time in Yale College, as assistant to Prof. Silliman, in what was called the Scientific School at that time, at Yale College; I was Professor of Chemistry in the National Medical College at Washington; Professor of Chemistry in the College at Kingston, Canada; Chemical Examiner in the United States Patent Office, where the subject of gas came before me practically.

442 Q. Have you given particular attention to the subject of the manufacture of coal gas?

A. I have, sir.

Q. Have you studied the subject of its purification?

A. I have, sir.

Q. Have you observed the subject of purification practically?

A. Within the last year I have spent a considerable amount of time on various occasions in examining processes of purification on the ground, if that is to be understood as studying it practically.

443 Q. Are you familiar with the lime process of purification—dry lime?

A. I am, sir.

Q. And with the method of purification by the oxide of iron?

A. Yes, sir, so far as a gas chemist can become familiar with it in this country, I presume; the only place that I am aware of where it is used being the works of the New York Gas-Light Company in this city, which I

visited on two occasions when they were using the process, and had permission to examine into the minutiae of its workings. 444

Q. The dry lime process of purification is that which is in use in the United States, is it not, sir?

A. So far as I am aware, with the exception of two or three gas works in which the wet lime process is used.

Q. One is in Boston, is it not?

A. One is at Boston and one, I think, at Providence, but the last account I received from the Providence Works they were proposing to substitute the dry lime. 445

Q. When was that?

A. Quite recently—within a fortnight—I heard the fact; I have no special knowledge, however, in the matter.

Q. I would like to ask you what are the results of your observations of the lime and iron processes for the purification of gas; you may speak of it in a scientific point of view, and also in a sanitary point of view?

A. With regard to the scientific points involved, sir, I would remark that I believe the ground has been so thoroughly gone over by Prof. Silliman, that I should have little to add, and the more especially so as a great portion of the same ground has already been gone over by me in print, and, therefore, I would propose to present a copy of a report made by me to the Manhattan Gas-Light Company during the last summer, made in manuscript, and which they printed about the first of December, or the latter part of November last, and of which I have some printed copies here. 446

Q. Will you produce a printed copy of that?

A. I have several here.

(Professor Wurtz produced a printed copy of the report, which was offered in evidence.)

Q. In that report do you discuss the claims of the two systems of purification—the lime and the oxide of iron?

A. I do, sir; I would remark with regard to this report, that in this report there is brought forward some

448 account, intelligible at least to gas chemists, of the new process which has been spoken of here previously by experts.

Q. At this hearing?

A. Which has been spoken of previously by other experts, not at this hearing, but a previous hearing; the process of the Manhattan Gas-Light Company; there is, however, no specification given to this process, as I understand the meaning of the term specification, in a technical and practical sense; in fact such specification
449 was purposely omitted by me; I did not feel authorized or called upon to present such a specification.

Q. Specification of what?

A. This method of purification; such a specification as would render it possible for a gas engineer to put it into practice.

Q. Do you mean of the Manhattan Company's process—of ventilating the effete lime?

A. Yes, sir; the question may be of the ventilation of effete lime; nevertheless the principle of the process
450 could be understood by gas chemists, and I should mention that this pamphlet has quite recently—within six weeks—been republished, or copied by the *London Journal of Gas-lighting*, and has consequently actually become a part of the current literature of gas.

Q. When was this report of yours published?

A. So far as my memory serves, it must have been about the 20th of November, 1868, that it was printed; it was circulated, though, I believe, only in a private
451 way.

Q. Have you any reason to alter your opinion now, as expressed in this report made by you?

A. The only essential addition that I would suggest is to add to the substances which are extracted largely by hydrate of lime from the gas, the constituent called naphthaline, which is not extracted to so large an extent by oxide of iron; allow me to read one of the paragraphs from this pamphlet.

Q. Which page is that?

A. On page 9 ; I present in the form of some conclusions, in one paragraph, this one : " It thus appears that of those constituents of crude coal gas which may be viewed as contaminations, and whose separation is desirable, there are no less than four of the most objectionable, which, while distinctly under the control of the lime process, cannot be shown to be separable by any recognized or reliable chemical or other agency residing in oxide of iron ; these four are carbonic acid, ammonia, bisulphide of carbon, and phenol ;" and to these I would now venture to add naphthaline. 452

Q. These four contaminations, then, you say, are distinctly under the control of the lime process, and are eliminated by it ; is that so ? 453

A. The results of the examination appear to show that ; I would also add, I find in my notes that I mention the nitrogenous and sulphuretted odorous matters of the gas which are complained of.

Q. What do you say about those ?

A. I have no reason to suppose that the oxide of iron retains these in any form, although they are largely retained by hydrate of lime. 454

Q. Well, then, I suppose you mean that the oxide of iron is a very imperfect purifier, a low purifier with regard to the carbonic acid, ammonia, bisulphide of carbon,—phenol, and naphthaline you would add ?

A. Naphthaline, and at least a portion of these specially odorous compounds which form the subject of complaint by the public.

Q. You adopt that pamphlet now, then, as part of your testimony in this case, and offer it as such ? 455

A. Substantially.

Q. Have you said all that you designed to say about it, in a scientific point of view, or is there anything further to be added in that respect ; if not, then you may proceed to state the result of your observations from the sanitary point of view ?

A. I would add the following remark :—in the present condition of the subject, a fundamental considera-

456 tion for the gas chemist is, that before any final decision as to the adoption of a method in a large gas works, on the smooth workings of which so much depends, a precise chemical solution should be arrived at of all the questions and problems involved; this would take time; realizing this I have recommended it to the gas companies, and especially the Manhattan Gas-Light Company; and I might add, that the chemist of the Board of Health, Professor Chandler, was invited to join in this investigation; this investigation has not yet, however, 457 made much progress; other matters have intervened.

Q. What is the state of that investigation now?

A. I regard all these proceedings *here* as a portion of that investigation, and an essential portion, an important portion, a valuable portion, and a fortunate portion, of that very investigation.

Q. What results will proceed from it, in your judgment?

458 A. The ultimate results, I doubt not, if it is carried on in a right spirit, and with diligence, will be the removal—the entire suppression of all the unpleasant consequences resulting usually from the impurities in the purification of the gas, and the improvement of the quality of the gas at the same time.

Q. Will you speak of the result of your observations of the lime and iron processes for the purification of gas from a sanitary point of view? What are the advantages or objections to each process?

458 A. First, I would prefer to make one or two general remarks. It is understood by myself, and, I believe, by the public generally, that formal and deliberate accusations have been brought against the Metropolitan Gas-Light Co., to the effect that they have been guilty of negligence affecting the health and the life of portions at least of the community. I regard these accusations as pure phantasy, while at the same time I would not deny the existence of a bad odor by any means. That would be absurd; quite as absurd in the opposite direction; neither would I deny the necessity of exercising all due

dilligence and exhausting science in preventing the 460
 escape of this bad odor—a subject which is occupying
 the attention, I may say, of gas chemists all over the
 world at the present time, but which is by no means
 satisfactorily solved, unless we may regard the process
 so very recently developed by the Manhattan Gas-Light
 Company as a solution. I may say, that I individually
 do regard that as a solution, and so stated in the pam-
 phlet referred to; and the other gentleman brought
 forward as an expert concurs, it would appear from his
 testimony, fully with me in this. I would add, that I
 have never met with any evidence pointing towards the 461
 truth of this accusation of any deleterious or detrimental
 action upon health, or any injury to health or danger to
 health, arising from the emanations from gas lime under
 ordinary circumstances. I have remarked that I con-
 sider this is a fortunate investigation. I consider it for-
 tunate to the Metropolitan Gas-Light Co., because it
 gives them an opportunity to purge themselves from
 these accusations of having injured the public health and
 endangered life. These accusations, if true, would
 really amount to accusations of a criminal negligence. 462
 I might add, that the experts who have testified in the
 case have already been attacked by implication in the
 newspapers, for aiding the Metropolitan Gas-Light Co.,
 and that is one reason why I make these deliberate re-
 marks. Now, with regard to the sanitary bearings. I
 will take the several substances in order: First, car-
 bonic acid. The view has been presented in the course
 of this investigation, that a small proportion of carbonic 463
 acid in the gas is of no importance in a sanitary point of
 view. I would say, in my opinion, as an expert, this
 remains to be proved, and that the probability is that
 anything which impedes the rapid and complete combus-
 tion of the gas in a confined room is extremely likely to
 be injurious to the health of the occupants of the room.
 To ammonia the same remark applies as to this; but at
 the same time I do not regard it as of any very great im-
 portance. Professor Silliman has already suggested an

464 important beneficial action which ammonia exerts when left in the gas, in neutralizing to a certain extent the products of the combustion of sulphur, which always remain in the gas in a greater or less quantity.

Of sulphide of ammonium. This is the most important constituent with which we have to deal, doubtless, in a sanitary point of view. Both the lime and the iron processes doubtless extract these completely from the gas when properly applied. The very fact that the oxide of iron process extracts it at all is a sufficient
 465 answer in the mind of chemists to the allegation that has been made that there is free sulphuretted hydrogen in the gas. It is difficult to understand how oxide of iron could absorb sulphuretted hydrogen—free sulphuretted hydrogen from the gas, except in the presence of an excess of ammonia, and then it becomes not free sulphuretted hydrogen, but sulphide of ammonium. The consideration of the sulphide of ammonium, then, is narrowed down to its effects in the material used for purification, and its after effects upon the atmosphere. In the case of
 466 oxide of iron purification. The effete iron, when taken out of the purifier, is believed to contain a large quantity of sulphide of iron. It may contain some ammonia. As Professor Silliman has already stated, it is well known that hydrated oxide of iron does absorb ammonia to a certain extent, though not by virtue of any definite chemical affinity that has ever been pointed out. As I understand it, just as clay, dust, or any finely divided material, as however, all the sulphide of ammonium is
 467 converted by the oxide of iron into sulphide of iron and free ammonia, and chemists would expect that some of the ammonia set free would travel on from the iron purifiers with the gas. I am not aware, however, that the chemical points involved in these considerations have been worked out satisfactorily. I am drawing inferences from theoretical considerations in a great measure. When the effete oxide of iron is exposed to the air, then we have a mass of sulphide of iron, which immediately attracts oxygen from the air, producing heat and burning. There is a danger here which seems inherent in

the process; that the heat may become so high as to set 468
 fire to the mass of sulphur, and sulphurous acid would be
 produced by the combustion of the sulphur. This danger
 probably increases in proportion as the mass has been
 revived and re-employed. It is alluded to in some of
 the works upon the subject, as a difficulty now under-
 going investigation, and being probably gradually
 mastered. I have here a work recently published by
 Zerah Colburn, on the "Gas Works of London, in which
 he states, on page 60: "Sulphuret of iron precipitates
 its sulphur on exposure to the air, and again combines 469
 with oxygen, occasionally with such energy as to take
 fire." On page 55, "the precipitation of sulphur and
 the resumption of oxygen are occasionally so rapid, es-
 pecially when the material has been used a few times,
 that it smoulders and actually enters upon active inflam-
 mation." In the latter case the sulphur vapor is almost
 overpowering. On page 57, "At the Commercial
 Works, however, Mr. Jones has his apparatus in readi-
 ness, and may have already commenced, indeed, to
 revivify Hill's oxide in his purifiers." The date of this
 is 1868. 470

Q. The author then is speaking of the method of
 purification by oxide of iron, is he not in this instance?

A. Yes, sir, in London. This is a practical work very
 recently published, and the impression gathered by a
 gas chemist is, that the subject of the revivification of
 oxide of iron is not yet reduced to such a certainty as
 to avoid with certainty this difficulty of catching fire
 of the great quantities of free sulphur which are thrown
 out of these purifiers, and the consequent diffusion of 471
 great quantities of sulphurous acid throughout the neigh-
 borhood of the gas works. In the case of the lime
 purifier, the sulphide of ammonium is largely absorbed
 as such, and appears to form a compound with lime, or
 with sulphide of calcium, as yet not investigated or
 understood by chemists. On exposure to the air this
 material undergoes oxidation also. The main substance
 given off being free ammonia, which carries with it,

472 however, some sulphide of ammonium. I have heard no evidence yet brought forward, and I have met with no evidence in all my readings of any deleterious effects from sulphide of ammonium. I have here a sample of sulphide of ammonium. Any gentleman can test the effect of it upon his nose and lungs by actual experiment. Here is a very concentrated solution of sulphide of ammonium, containing, as it almost always does, when it has been standing some time, free sulphur in solution, indicated by the yellow color, and some
 473 sulphide of ammonia. I am enabled also to present a solution containing sulphurous acid, upon which some remarks have been made here, and upon which I have some further remarks to make, as an exhibit to be tested by gentlemen who are now familiar with it. The effect upon the nose and eyes is very distinct, though the odor is not very strong, and the effect upon the throat is very marked in producing a choking sensation, and if persisted in for a few inhalations, very violent fits of coughing are produced. This gas is simply the same as is
 474 given off by a brimstone match, familiarly known as fumes of burning sulphur—brimstone fumes—and the suffocating quality of which every one is familiar with. I shall have more to say about it subsequently.

The next substance which I wish to speak of is phenol. I am not aware that phenol is absorbed by oxide of iron. I am not aware either that its presence in the gas is detrimental either to the illuminating power, or in a sanitary point of view, but it is well known to be
 475 absorbed with some considerable power by lime, having an affinity for lime by virtue of its analogy to alcohol, and forming a weak compound, somewhat similar to what are known as alcoholites. When the effete lime is exposed to the air the phenol is doubtless given out again, sooner or later, from the absorption of the carbonic acid by the lime, to the displacement of the phenol. I should consider it preferable that it should be given out in this way, rather than to be distributed with the gas to the consumers, as its odor is disagree-

able to most persons and extremely persistent, and has 476
 the nature of adhering to substances for a long time, as
 every one who has ever had the toothache knows famil-
 iarly, who has used it for curing toothache; it is gene-
 rally called creosote, although it is not creosote, but it
 is sold for creosote, and used for the same purposes,
 and is similar to it. Gas containing phenol, when leak-
 ing, as gas is very likely to do, or let out into the atmos-
 phere, would doubtless have a tendency to leave a per-
 sistent odor more than well purified gas. Phenol is
 accompanied by other substances, one of which is known 477
 by the name cresol, which has a somewhat different odor,
 but at the same time very persistent.

The next substance I wish to speak of is naphthaline.
 Naphthaline appears to be absorbed largely both by
 the oxide of iron and by the lime. There is always
 danger of too much of it being absorbed by the gas.
 Its illuminating power being very high, one of the evils
 of over purification is the abstraction of too much naph-
 thaline from the gas, and the impoverishment of it. At
 the same time it is dangerous to leave very much naph- 478
 thaline in the gas, particularly when the gas is not of
 a very high illuminating power. Poor gas containing
 much naphthaline frequently would deposit naphtha-
 line in the main, and endanger the supply to the com-
 munity by choking the mains; hence I should prefer a
 process which would abstract from a very rich gas
 enough naphthaline to prevent this danger, and not
 abstract enough to impoverish the gas. Gas engineers
 have generally found the lime process to answer these 479
 requests. When a poor gas is in question, experience has
 shown that naphthaline has a tendency to deposit in any
 case.

The next substance is bisulphate of carbon. There
 is much difference of opinion as yet among gas chem-
 ists about the relations of this substance to gas, which
 I attribute to the overlooking of many of the results of
 the earlier investigators of the substance. I have gone
 back to those older writings—those of Berzelius and

480 Zeise on this subject. Not to go into the chemistry of the subject in detail, I will merely say that we have here evidence sufficient to justify us in believing that hydrate of lime extracts all the bisulphate of carbon from gas.

Q. How is iron, the oxide of iron, acted on?

A. There is no evidence of any action upon bisulphide of carbon by this.

Q. No affinity between the oxide of iron and the bisulphide of carbon?

481 A. Not that I am aware of. Bisulphide of carbon is an especially dangerous and injurious substance in gas, as it is not detectable by any simple means—as lead paper for instance. Second, it is inodorous. When pure, almost inodorous. In the atmosphere it decomposes and developes an insupportable odor, the cause of which is not well understood, probably owing to the development of hydrogen compounds; as I may say Prof. Silliman has recently pointed out in an item published in the *American Gas-Light Journal*. Bisulphide of
482 carbon, when burning, is converted into sulphurous acid; the sulphur in it is converted into sulphurous acid. There is no reason to believe that it does not undergo perfect combustion in gas. The combustibility, so to speak, of sulphur, may be said to be greater than any other of the constituents of gas. It probably is burned first into sulphurous acid.

The next class of substances are the odorous compounds. These pass chiefly into the tar in all cases.
483 If the gas be scrubbed with water, after it is evolved from the retorts, as it is by the Metropolitan Gas-Light Company, more tar is deposited, and my observations have convinced me that I may say that these odorous compounds are condensed at that stage of the operation. Inferring from the well-known fact that woollen substances have great power to condense these odorous materials—these persistent odorous substances which are found in smoke, say for instance—tobacco smoke; inferring from this that an instructive experi-

ment might very readily be made, I took a blanket 484
 shawl which I have here, and which any one will see at
 a glance is very appropriate for the purpose, and spread
 it out in the fumes from one of the fouled purifiers of
 the Metropolitan Gas Company, which had been opened,
 and was giving off the stench very perceptibly. This
 shawl I carried with me and wore it a part of the time
 afterwards, and tried to distinguish at intervals the
 odor which I supposed would be absorbed. I could
 not recognize any such odor in the course of, to the
 best of my recollection, about three hours afterward. 485
 I do not mention this as a conclusive test. It is only a
 very imperfect test. I judge from it, however, that
 there is much less of this intensely odorous substance
 evolved from these lime purifiers when the gas has
 previously been scrubbed by water, as is practiced
 by the Metropolitan Gas-Light Company, for the
 reason that on previous occasions, when I have been
 exposed to the effluvia from opened lime purifiers, or
 even from that which generally floats from the atmos-
 phere of a purifying house to some extent, I have re- 486
 tained the smell about me for twenty-four hours, as
 near as I can recollect. These were instances where
 the gas had not been previously scrubbed with water.
 In previously scrubbing, the impurities had been con-
 densed and did not reach the lime. I may say that I
 was surprised by the result, because I expected on this
 instance to carry the smell with me. I supposed this
 shawl was a peculiarly favorable fabric to absorb and
 retain it. I should conscientiously add that I have 487
 heard that the New York Gas-Light Company also
 scrub their gas as it comes from the retorts. I should
 like to ask Prof. Chandler whether he knows this is a
 fact or not?

Prof. Chandler: I believe I do.

Prof. Wurtz: And this would account for the com-
 parative absence of these concentrated odorous sub-
 stances, when the iron oxide purifiers are open, and
 account for the discrepancy between the statements

488 made by experts here, with regard to the comparative absence of these foul odors from the effete oxide of iron of the New York Gas-Light Compony, and the opposite published statements made by English authors, Dr. Bowditch and Dr. Letherby, for instance. This, however, has no bearing upon the question as between the oxide of iron and the hydrate of lime process. This is a question apart. It has, however, a bearing upon the accusations that have been made against the Metropolitan Gas-Light Company for not exercising due diligence and not taking due precautions to avoid offending the noses of the public. The gas itself is another material given off when the purifiers are opened in both cases. This contains carbonic oxide, a dangerous and well-known violent poison. I have not found that it is pretended, however, by any one, that the carbonic oxide given off from open purifiers, has ever produced any injury to any one. The supposition is simply absurd, from the fact that it is instantly diffused radially, and that its toxical efficiency must decrease as the light from a candle decreases, for instance, by radiating from the centre, so that at a very short distance it becomes so diffused and so diluted that no chemist could detect it in the atmosphere any longer. With regard to sulphide of ammonium, I would suggest that the same remark applies; that the dilution of the material, in diffusing through the atmosphere, must increase as the square of the distance, not simply as the distance; consequently, in a very great geometrical ratio. This was shown by the experiment the results of which have been already exhibited; in the specimens of lead paper, seventy-five feet from the purifying house when the purifier was in full process of oxidation. From a freshly open purifier, at the distance of seventy-five feet, the delicate test lead paper no longer detected sulphur in the atmosphere. The question between the lime and the iron process seems, to me, to narrow itself down as between the alleged nauseating effects of sulphide of ammonium, and the admitted irri-

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tating and suffocating effects of sulphurous acid, although 492
 in minute quantities. Those who have tested these two
 materials here, will be able each to form his own judg-
 ment upon these two points. I am willing to admit the
 nausea, though with me the effect is exactly the opposite.
 Tobacco smoke, for example, is said to produce both
 effects—the nauseating and the stimulating, upon dif-
 ferent persons, and also upon the same person at differ-
 ent times, I believe. Yet, it is scarcely proceeded
 against as a nuisance dangerous to health, unless in- 493
 flicted to an excessive degree. Yet a word or two more
 with regard to sulphide of ammonium, before I leave it.
 It may not disappear simply by diffusion. The chemi-
 cal books might be extensively quoted from, to show
 that it is an admitted fact that sulphide of ammonium
 oxidates in the air, forming hyposulphite of ammonia.
 I have in my notes a reference to Gmelin's Hand-book,
 supporting this statement, but as I am confining myself
 to the sanitary points I shall not present chemical refer-
 ences. I wish to remark here, however, that this would 494
 assist the process of diffusion, in actually destroying the
 sulphide of ammonium very rapidly, but I wish more
 particularly to point out that in the open atmosphere
 there is ozone, which very quickly destroys sulphide of
 ammonium. In the confined space of a room there is
 no ozone. Here is an important point which has not
 been considered by many of the chemical experts who
 have written upon this subject. This same remark might
 apply to the disappearance of sulphuretted hydrogen if
 it were set free from the fouled purifiers when opened.
 But I should regard that question as having been fully 495
 disposed of, it having been fully conceded that the
 effluvia from the effete lime contains an excess of am-
 monia, and no free sulphuretted hydrogen, and I have
 also presented, myself, evidence drawn from the iron
 process itself, that no free sulphuretted hydrogen can be
 present, as such, which would be absorbed with cer-
 tainty by the oxide of iron according to any principle
 that I am acquainted with.

496 The main point remaining with regard to the sanitary bearing, relates to the nature of sulphurous acid. I must admit in giving conscientious evidence, that I differ somewhat from many chemists of my acquaintance, on the poisonous power of sulphurous acid. I believe that it is under estimated. I believe that there is a class of men who are constitutionally insensible to the usual effects of sulphurous acid upon the mucous membrane of the air passages. Individually I am an example, and I believe in common with a great majority of mankind,

497 of extreme sensitiveness to the action of the most minute quantities of sulphurous acid in the air. There are proofs however on record of the poisonous nature of sulphurous acid in very minute quantities which can be cited. I am referring, for instance, to the frequent and protracted cases of litigation, particularly in European countries, concerning the effluvia given out by metallurgical furnaces, copper furnaces, particularly, the deleterious effects of which spread for miles around. I found that even with this radial diffusion and this decreasing inversely as the square of the distance, of the quantity in the atmosphere, yet sulphurous acid is still detrimental. In conversation it has been remarked to me that I overlooked, in taking this view, the presence of arsenic sometimes in these effluvia. I did not overlook it. Arsenic is given off in the form of arsenous acid, which is not a gaseous substance. It is a solid substance, which is very quickly deposited, and cannot diffuse itself to a distance of miles. Yet there is abundant evidence

499 on record of the diffusion of this actually poisonous influence, both upon plants and animals about those furnaces where sulphuretted ores are burned—are roasted, to the distance of several miles. In one place a nobleman's park in Great Britain was entirely destroyed, root, leaf and branch. These facts must be explained. I explain them in this way. Sulphurous acid is what is called a cumulative poison, in the language of toxicologists. It is absorbed by water—by moisture and moist surfaces, with gradual accumulation upon such surface.

It is absorbed by rain and deposited upon moist surfaces. 500
 In this manner it destroys the leaves of plants doubtless.
 It is converted into sulphuric acid by oxidation, to some
 extent at least, slowly—probably very quickly in the open
 atmosphere, by the action of ozone. I am verging upon
 the chemical points, so that I will not pursue this further.
 I think I have said sufficient to illustrate my views
 upon that head. My belief is that the use by the last
 generation, so universally, of brimstone matches, has
 given rise to a dangerous indifference to the inhal-
 ation of sulphurous acid in small quantities, and that 501
 the next generation will recognize the view I have
 taken of the question, that it is one of the most
 toxical gases, even in small quantities, to whose
 attacks human beings are liable in ordinary life. I
 would add that I am told that the French laws have
 prohibited the evolution of sulphurous acid from the
 smelting furnaces into the atmosphere at all, in conse-
 quence of their recognition of the poisonous character of
 this gas. In the pamphlet which I have presented in 502
 evidence, the effect of sulphurous acid when set free in a
 confined space like a room, for instance, are alluded to, in
 the case of the Metropolitan Under Ground Railway in
 London, in which it is averred on good medical author-
 ity—the authority of medical experts called in the trials
 which took place—that the sulphurous acid was the
 cause of the deaths that have occurred, and in the course
 of this trial Doctor Letheby asserted as the results of his
 experiments that one part of sulphurous acid in 100,000
 of air, is perceptible to the taste and will produce cough- 503
 ing. Dr. Odling, in one of his earlier statements on this
 subject, presented some views which have been cited
 here, to which I strongly object in many ways. The
 article which I allude to has been cited in the *New York*
Times of February 12th.

Q. The extract from Dr. Odling's lecture ?

A. Yes, sir.

Q. Very well, what do you say about that, Profes-
 sor ?

- 504 A. Dr. Odling makes a calculation here, which I have not critically examined, but he presents the point that the fact that the sulphurous acid produced is diluted with a thousand times its volume of carbonic acid, it is liable to render it less poisonous. Dr. Odling has overlooked the view that I have presented of the cumulative character of sulphurous acid as a poison; and taking that into consideration, I would regard its dilution with carbonic acid merely as calculated to intensify its toxical action and make matters worse. The depressing effect
- 505 of carbonic acid upon the system is well known, and if you add sulphurous acid, with the irritating effects of the sulphurous acid upon the air passages, you have a combination of circumstances very unfavorable to health. There is no doubt that in the upper portions, as Professor Silliman has already stated, of crowded assembly rooms, where gas is burned extensively, such as theatres, churches, ball rooms even, and many other similar places, these injurious gases produced from the gas burners, would exist in much larger proportion than Dr. Odling
- 506 admits here. That is another point which he does not take into consideration. His supposition that the amount of ammonia ordinarily existing in the atmosphere can neutralize 20 grains of sulphur in the gas, strikes me as simply absurd. I have calculated that for neutralizing 20 grains of sulphur, if converting it into sulphate of ammonia is a neutralization, it would require 21 grains of ammonia. Every chemist who knows that an ordinary atmosphere contains an amount of ammonia almost infinitesimal, will see the unreasonableness of Dr. Odling's
- 507 suggestion here. One hundred cubic feet of gas containing 20 grains of sulphur—or 45 as Professor Chandler has stated, I think, was contained in the New York Gas-Light Company's gas purified by the oxide of iron—100 cubic feet of such gas would require very nearly 50 grains of ammonia to convert its sulphur into sulphate, or sulphite of ammonia.

Q. I want you to state in as few words as you can the inefficiency of the oxide of iron process of purification to

eliminating these contaminations, and the efficiency of the lime process to eliminating them—briefly, and as it is affected by this question of sulphurous acid of which you have been speaking. I wish a practical application made of what you have said there of the poisonous character of sulphurous acid, and how it is affected by those two systems of purification, or how the two systems of purification bear upon it? 508

A. It is in evidence from the researches of chemists that bisulphide of carbon, as well as the sulphide of ammonium and other sulphuretted compounds detectable by lead paper, should be completely absorbed by hydrate of lime. There is no direct evidence that oxide of iron can absorb all the sulphide of carbon. 509

Q. Now, then, the bisulphide of carbon and the sulphide of ammonium being left in the gas, after it has been subjected to the action of the oxide of iron, where and under what circumstances do other injurious effects present themselves?

A. When the gas is burned, according to the experience of all mankind. 510

Q. When the gas is burned in dwelling-houses or public places the presence of these contaminations is then experienced in the form of what?

A. Sulphurous and sulphuric acid; the weight of evidence is so great on that point as to make the facts notorious.

Q. And which are destructive to property?

A. Destructive to property, irritating to the air passages of most persons, and peculiarly so in crowded places, and especially in the upper portions of the atmosphere of such crowded places. 511

Q. Now then, what kind of gas would you call that to be which exhibits the presence in it of from 21 to 45 grains of sulphur per 100 cubic feet?

A. I should regard such gas as objectionable; I should prefer such gas as was purified down to 20 grains, or as low as possible; down to 10 or 12 grains, as the Manhat-

512 tan Gas-Light Company, for example, claim to purify their gas.

Q. I will ask you the question whether you consider the emanations and exhalations from the spent lime, when the purifiers are open, as deleterious to health?

A. I cannot view them in any light which will justify such an estimation of them; I am not aware of the slightest evidence which would justify any such view.

Q. Now, then, you have been present at the New York Gas Works—you have been at the New York Gas-
513 Works where the oxide of iron process of purification prevails?

A. I have, sir.

Q. Have you been there when the purifiers were opened and the foul iron was exposed to the air?

A. I have.

Q. Will you state, if you please, whether they gave any odor, and if so, what was the character of them?

A. I perceived the characteristic odorous substances
514 which have been the subject of complaint, but not to so great an extent as I have perceived them on other occasions about large gas works.

Q. Are they not inevitable—the presence of unpleasant odors with the purifying material, whatever it may be, as far as your experience extends?

A. I have seen purifiers opened at large gas works—

Q. I mean such as you have spoken of?

A. I have seen purifiers opened in large gas-works
515 when these odors were so slight that they might be called imperceptible.

Q. What gas works was that?

A. In the Manhattan gas works.

Q. That is where this new system of ventilation of which you have spoken prevails?

A. Where the effete lime was thoroughly ventilated by the passage of the air through the closed purifier, and the mass converted into a porous substance something like chalk, and inodorous; a specimen of it has been produced here.

Q. You have visited the works of the Metropolitan Company ? 516

A. I have on several occasions.

Q. I wish you would state your general conclusion as to the management, manipulation and products of the Metropolitan Gas-Light Company ?

A. I have made several visits. One of them was on the 30th of January, 1869, when a fouled purifier was opened especially for me at 10.30 in the morning. This purifier was 20 feet by 20 and with six tiers of trays. It contained between 200 and 250 bushels of lime, and very nearly 1,000,000 feet of gas had been put through this lime during the 24 hours immediately previous; atmosphere of purifying-house strongly ammoniacal and distinctly stimulating. 517

Cassidy, the foreman, stated that he had been six years in this purifying-house and seventeen years in all in the same employment, having come from the Manhattan Works ; was 56 years old—appeared robust and with healthy and florid complexion ; stated that the men under him were all strong and uniformly healthy, but suffered from temporary irritation of the eyes from the strongly ammoniacal atmosphere when the boxes were being emptied of gas not over purified, as it still indicated small traces of sulphur and ammonia.” 518

I would remark, that I ascertained on that occasion that the time of cleaning these large purifiers was about one hour, which is a very short period, if I am not mistaken, and indicates diligence in getting their material out of the way as much as it can be. I collected some samples upon that occasion which have already been exhibited here. Subsequently I made a visit together with Professor Silliman, on which we have made those important tests with lead papers and made a thorough examination of the works. I agree with Professor Silliman in the general conclusion that the management of the Metropolitan Gas-Works is quite as careful and cleanly as is compatible with the working of so large an establishment. Excepting this one point, which might be ex- 519

520. cepted, relating to the ventilation of the lime in the purifiers, which I regard as entirely extraneous to this question; a general answer would be that the management and manipulation of the Metropolitan Gas-Works is as careful and as cleanly as that of any other large gas works which I have visited.

Witness: I would ask the counsel whether he wishes the question to relate to the future course—whether he wishes to ask my opinion as an expert as to what should
521 be the future course of the Metropolitan Gas Light Company.

Judge Van Vorst: No; that is not in relation to this question.

Q. You have stated that the oxide of iron has no affinity for, and does not remove the bisulphide of carbon; is that so; what would be the effect of subjecting the gas, after the oxide of iron had acted upon it, to the
522 hydrate of lime or wet lime; what effect would that have upon it; what office would that agent perform, and how would it affect the gas to be delivered?

A. It would depend upon the quality of the gas; it would depend upon the richness of the gas.

Q. What effect would it have upon the illuminating power of the gas?

A. It would decrease the illuminating power of the gas inevitably; it would amount to over-purification, technically so-called by gas managers.

523 Q. And over-purification has a deleterious effect upon the gas, has it not?

A. Upon the illuminating power of the gas.

Q. Then there is such a thing as over-purification of the gas?

A. There is.

Q. And that would be the effect of subjecting the gas to this double method of purification of the iron and lime afterwards?

A. It would.

524

Q. Now, Professor Wurtz, I desire to ask you, as an expert, your opinion as to the suggestion that has been made to substitute the use of the oxide of iron for lime by the Metropolitan Companies as a method of purification?

A. I think it incumbent upon gas chemists and upon the whole community to be taught by past experience in deciding such questions; we are now repeating a chapter of history here—a chapter of history which has been passed through by the gas manufacturers of Great Britain more particularly, and even to some extent, by our largest company—the Manhattan Gas-Light Company. Complaints relating to this so-called nuisance, from municipal authorities, have been abundant in all civilized countries where large cities are lighted by gas. In England this was carried to such an extent that the gas companies were brought up so often as nuisances before the Police Courts, that they adopted the use of the oxide of iron, thinking that in that way they could get rid of a portion of the smell, and make matters better. The tendency, however, at the present time, is to go back again. The first result was that the amount of sulphur increased in the gas. I wish to add here with regard to bisulphide of carbon, that it is considered by gas chemists as a very slippery thing. The same coal from the same heap varies very greatly in its product of bisulphide of carbon; sometimes the quantity being so very great that it is stated the gas will give off the smell of brimstone matches. The point which I wish to bring forward is that bisulphide of carbon may occur in gas occasionally to a very large extent owing to causes as yet unknown. Sometimes a coal which is found by analysis to be comparatively free from sulphur will give a very sulphuretted gas, from which the sulphur cannot readily be removed by the ordinary modes of purification. Until we know more about bisulphide of carbon, I think I would be cautious in substituting for the agent—the hydrate of lime, which is known to absorb it—any other agent which is not known to absorb it,

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528 I wish to make one or two further remarks. I have already spoken of the danger also of oxide of iron catching fire, which seems to be spoken of as one not yet entirely mastered by our gas chemists.

Q. Is there a danger to be apprehended from the oxide of iron catching fire?

A. Where a vast mass of it is used, as would be in a large gas works like the Metropolitan, and it is kept lying about, I should regard it as a danger which must be taken into consideration in advance of any extended or
529 continued series of experiments upon the subject.

Q. What is its liability to take fire attributable to—to the presence of what in the iron do you attribute that?

A. To the presence of sulphuret of iron or sulphide of iron. The effects of its taking fire is to give off large quantities of sulphurous acid which would render the atmosphere of the neighborhood of the works intolerable.

Q. That would be the effect of it?

A. Yes, sir; with regard to the management of the Metropolitan Works, there is another point I find that I
530 noted down in reference to statements that have been brought forward, which I believe are rather ancient, being taken from Ure, of men having been suffocated in sewers, wells and pits, and so on, by the emanations from waste lime. I would simply remark, that the only reasonable inference to be drawn from this, is that the waste lime should not be used in that way to fill up such places; that it should be managed precisely in the way that the Metropolitan Gas-Light Company do
531 manage it. It should be spread out in the open air so as to become ventilated and oxidized, and the sulphur compounds destroyed, so that they cannot collect together in depressions and cause danger and produce death in that way.

Q. I ask you whether you observed in the neighborhood of the Metropolitan Gas Works any causes which would be likely to produce contaminating or deleterious odors?

A. On the occasion of one of my visits I smelled a

very putrid odor which I was informed proceeded from 532
an establishment for the boiling up of carcasses of dead
horses, the location of which was pointed out to me, and
from which the wind at that time blew directly, as I ob-
served.

Q. Where was that establishment?

A. At the foot of Thirty-eighth street, three blocks south

Q. Was it such an odor as would be likely to pro-
ceed from such a cause as that?

A. I should have said I perceived it on two occasions.
On one occasion Professor Silliman was with me, and he
pointed it out to me, and we both remarked its entire
distinctness from the odor of the gas works. The wind
was blowing in such a direction that no smell could
come from the gas works.

533

Q. Was it an odor that would be deleterious to health?

A. I should think it was an odor decidedly deleterious
to health. There is another large establishment that is
known by the name of a piggery. I did not go inside
of it, but I infer also from the odor, which was the usual
odor of a pig sty.

Q. How near?

A. Next door to the Metropolitan Gas Works.

Q. It extended how far?

A. It extended nearly the whole of the long side of
the block between 11th and 12th avenues. I wish to
add, that I have consulted some of my chemical friends 534
about this question as to the character of these odors,
which are known to spread through the city on certain
occasions, and I have found several who have concurred
with me in the idea that they were not always from the
gas works; that there are odors which spread over New
York from other sources, and which they recognize as
such, sometimes as the smell of putrid matter. I think
the gas works have received the blame of all these things.
Injustice has been done them to that extent. I would
add, I believe it comes under the present head that we
are talking of, that there would be considerable difficulty
and injury in at once arbitrarily changing the system in
use by the Metropolitan Gas Works at this season. It

535 could only be done at a season when the consumption of gas is at a minimum.

Q. What season is that?

A. In the spring, I suppose, in April.

Q. Have you stated already when the process of ventilation of effete lime in use by the Manhattan Company was first made known to the public?

A. It was first really made known to the chemical public by its publication in the *London Journal of Gas Lighting* during the last month, the preceding month of

536 January.

Q. Of this year?

A. Of this year. It has really not been made known to the general public in such a form as to be available practically at all.

Q. There have been no specifications of it published?

A. There have been no specifications.

Cross-examined by Mr. Bliss :

Q. In your opinion, is there any necessity for the Metropolitan Gas Company to conduct its operations of
537 the manufacture of gas in a way that gives off the offensive odors that are given off when its purifiers are changed?

A. Not permanently.

Q. Had they on the 14th of July last, or the 15th of July last, gone to work to remedy the offensiveness, could it not have been done long before this time?

A. Well, I am not really bound to answer a question which relates more especially to gas engineering. I do not feel competent to answer. The impression on my
538 mind is, that they might have done it; it is merely an impression, that is, if they had the specifications before them.

Q. Is not this process of purification by ventilation a modification of Palmer's process, which has been known for a long time?

A. I should say not. It is an improvement, an additional attachment or appendage to the Palmer process, and throws out also some portions of the Palmer process.

Q. Is it a patented process? 539

A. I do not know whether it is or not. I have no right to know anything about that.

Q. Is there any difficulty in any other gas company gaining the means necessary to put that process in operation, I mean by inspection there?

A. There is no difficulty in their gaining a knowledge, I presume. I know of no such difficulty. The Manhattan Gas Light Company have offered no obstacles to inspection, so far as I am aware, although I am not familiar with their police regulations, but as to their being able to do it, that depends upon conditions that I am totally ignorant of. 540

Q. What conditions?

A. That was answered in my previous answer, as to whether it is patented, or is going to be, or is caveated.

Q. Suppose the chemist of the company goes there tomorrow, can he get access to the information necessary to put this process in operation? 541

A. I cannot answer that question; I have no authority to answer for the Manhattan Gas Company.

Q. Then, if there are no means, to your knowledge, of putting that process in operation, we will leave that out of the question?

A. I do not know that I am to decide as to whether we will throw that out of the question or not.

Q. How long has that process been in operation in the Manhattan Company?

A. I am not familiar with the history of it, except in a very general way, and by hearsay. I have been informed that, in its present form, it has been in use some two or three years. 542

Q. At the Manhattan works?

A. Yes, sir. In a form somewhat approximating to what it is now. I am told it has been longer in use, but I could not give the details. The Manhattan Company has made many experiments. They have tried the iron process very extensively, and failed to succeed with it.

543 Q. That I do not want to go into ; I confine myself to one class of questions at a time. Has not the ventilating process, as applicable to the additional purification of gas, been known to gas engineers for a long time?

A. It has been known, but unfavorably.

Q. And no favorable process known until this was got out?

A. Not that I have heard of. There have been dangerous accidents frequently from the attempts.

544 Q. Which of the processes now in use in this city, of manufacturing gas, is in your opinion the least offensive?

A. I have no hesitation in saying the process in use by the Manhattan Gas Light Company.

Q. Which is the next?

A. I am not familiar with the process used by the Harlem Company.

Q. I confine myself to the Metropolitan, New York, and Manhattan ; the Manhattan is the best, you have have said ; now which is the next, in the sense of being

545 the least offensive?

A. To whom?

Q. The least offensive in the process of manufacturing? this order expressly says, or it speaks of, the process of manufacturing ; it looks to that.

A. I cannot answer the question ; I have never made but two visits to the New York Gas Light Company when they were opening the purifiers, and I cannot speak from so little experience and observation.

546 Q. If you cannot speak as to that, how could you speak so in your pamphlet, and in your testimony as to the merits of these processes—of the New York Gas Company's process?

A. Simply because I observed the facts stated in the pamphlet ; I observed an offensive smell.

Q. But you did not observe sufficiently to enable you to say whether that process was more offensive than the Metropolitan Gas Company's process?

A. I will make an answer to this point—which I

presume ought to be satisfactory : that on the occasion 547
on which I visited them for this special purpose, the
New York Gas Light Company's works, and the Metro-
politan Gas Light Company's works, that on these special
occasions I observed a worse smell at the Metropolitan
Gas Works than I did at the other, as far as smell is con-
cerned.

Q. And your knowledge as to the matters connected
with the iron process, you derived from what knowledge
you obtained at these two visits ?

A. I cannot say that.

548

Q. Have you had any opportunity of ascertaining the
effect of the New York Company's process, than you have
had as to the question of its offensiveness ?

A. As has been remarked here before, there are many
iron processes.

A. I am talking of the New York Gas Company's iron
process ; have you ever had any more opportunity ?

A. Not of that special modification ; I have not.

Q. In changing from the lime process to the iron pro- 549
cess, is anything more needed than only changing the
purifiers, and removing the trays, and putting in iron
instead of lime ?

A. That is strictly a question for an engineer to de-
cide ; the difficulties met with would probably be more
in the collateral and auxiliary arrangements, or fixtures
necessary, than in the mere cleaning out of the lime and
putting in iron.

Q. What fixtures do you refer to ?

A. As I stated before, I am not specially familiar with 550
the New York Company's process ; I have seen their
material spread out on the floor of their purifying house,
and in the open air, but I cannot state how much space
they require to spread it out.

A. I am talking about the space they require for re-
vivifying ; supposing they desired to change the iron
process, would they need anything more when the pu-
rifiers were changed, than to take out the trays and put
in iron instead of lime ?

551 A. I should regard that merely as a question to be decided by reference as to the facts of what the New York Company did under the circumstances—the modifications of their machinery.

Q. Is that the fact, that that was all the change they made?

A. I could not say whether the New York Company made any change in their fixtures.

Q. Then anything you have said as to the impossibility of the Metropolitan Company's changing to the
552 iron process, you do not know, as a fact, whether they can or cannot, nor as to the time it would take?

A. So far as the mere substitution of the iron for lime is concerned, I could not.

Q. Accepting the fact that the iron can be substituted for the lime, what other thing is there involved in the change, which will take time; is there anything more than a sufficient space for the revivification of the iron?

A. In answering that question the most prominent
553 point that comes to my mind is as to whether they would be able to command trained workmen, familiar with the iron process.

Q. Does it require any trained workmen?

A. I should think it extremely probable it did; my experience is to the effect that no modification, in any great manufacturing operation, however small, can be carried on, however simple, without trained workmen.

Q. Do you know, as an actual fact, that at the New
554 York Gas Works the men are not trained?

A. In the peculiar process relative to the iron: I do not speak of mere laborers; I mean the men who are relied upon to see it—the responsible men who are competent to meet any unlooked for contingency.

Q. Do you not know that the parties controlling the process in use at the New York Gas Works have made an offer to furnish all the assistance necessary to introduce that process elsewhere?

A. It may be so, but I have not encountered the in- 555
formation.

Q. Have you not seen their circular ?

A. I have not, that I remember ; I have not read it.

Q. Are not all the processes used in this city by the
three large companies for the manufacture of gas un-
healthy ?

A. I should regard the iron process as having a tend-
ency to affect the public health injuriously.

Q. In what way ?

A. By leaving the sulphur in the gas. 556

Q. You mean by introducing it into the rooms ?

A. Yes, sir.

Q. Now, taking that iron process and applying
lime to it subsequently, would it then remain un-
healthy ?

A. Probably not, it would only affect the eyes of the
public.

Q. The effect would be deleterious to the illuminat-
ing power of the gas, would it not ? 557

A. I should apprehend that it would.

Q. Then, if the companies were required to introduce
that ventilating process of lime, after the iron, and were
required to furnish for a given sum of money, the same
illuminating powers, the only deleterious effect would
be upon the stockholders, would it not ?

A. That is scarcely a question for a chemist.

Q. Unpleasant odors are not unavoidable in the prac-
tical manufacture of gas ?

A. It has been recently so discovered by the Manhat- 558
tan Gas-Light Company.

Q. And that by the process which has been in use
two or three years ?

A. Secretly ; that is, it has not been a matter of pub-
licity.

Q. Has there been any difficulty in any way, so far
as you know, of gaining access ?

A. Not so far I know ; I have found the doors open.

Q. Why did you say secretly ?

559 A. Secretly may be too strong a term; I mean, privately—it has not been a matter of publicity.

Q. Have all of the gas companies and yourself known all about it?

A. I think not, from the fact that I have talked with officials of the gas companies, who, until quite recently, had not understood the nature of it.

Q. What officials do you refer to?

A. That I do not think I should be called upon to say.

560 Q. Any officials of the Metropolitan Gas Company?

A. No, sir; I could not specify any officials of the Metropolitan Company.

Q. Was or was there not any one of that Company?

A. I do not remember any especial individual.

Q. When were you consulted by the Metropolitan Company with reference to any question connected with their manufacture of gas?

561 A. I could not remember the precise date; the president of the company called upon me first in connection with the matter some time in August last, I believe.

Q. What then happened—was there anything more than asking you to suggest something?

A. The salient points of that interview which recur to my memory are, that the president desired me to recommend to him some gentlemen who would be competent to take up the investigation of gas purification, with a view to the improvement of their process.

Q. At that time you knew the Manhattan gas process was in operation?

562 A. At that time, yes, sir; previous to that I had been examining it.

Q. You satisfied yourself it was successful?

A. I was not so strongly decided about it as I became afterwards; I was making up my mind in that direction.

Q. After that time, when did you first do anything further in connection with the Metropolitan Gas Company's process?

A. Not until within a few weeks ; I was not called 563
upon until within a few weeks ; I cannot remember the
precise date at this moment.

Q. Have you not a personal knowledge of the iron
process in use abroad ?

A. I have not, sir ; from observation.

Q. You do not know how the New York Company's
process bears comparison with them ?

A. Not from observation—no, sir.

Q. You heard Professor Silliman's testimony ?

A. I was present at the whole testimony, I believe ; I 564
heard most of it—yes, sir.

Q. Is there any portion of it you disagree with ?

A. There may be some minor chemical points in-
volved in which I did not agree with him ; I have al-
ready alluded to one point—as to my estimation of the
actual poisonous character of the sulphurous acid in
small quantities.

Q. Is there anything else that occurs to you ?

A. There were other points which I really cannot re- 565
collect at this moment.

Q. Anything of any importance ?

A. Nothing of any essential importance bearing upon
this question, that I recollect.

Q. You spoke of ozone in the atmosphere—is there
any great quantity of ozone in the atmosphere of cities ?

A. It is very varying as a general thing ; it has been
found in the atmosphere of cities constantly by tests
applied.

Q. Is not its amount very much less than in country 566
atmosphere ?

A. Its amount is small, but it is believed to be con-
stantly present and constantly reproduced.

Q. Is it not much smaller than in the atmosphere of
the country ?

A. I do not recall the facts distinctly enough at this
moment ; my impression is that it is so—that in cities it
is usually smaller than in the country ; that depends
upon the proximity of the sea coast, I think.

567 Q. Do you consider yourself a sanitarian?

A. Only so far as I have had my attention drawn a good deal in the course of my studies, and in my practice; though to subjects rather connected with therapeutical subjects than sanitary.

Q. How as to physiological matters?

A. I could scarcely call myself a thorough physiologist—toxicology I have studied pretty thoroughly—the science of poisons.

568 Q. Is not anything injurious to health, in a greater or less degree, which changes the natural composition of the atmosphere we breathe?

A. I do not know that I got the full sense of the question.

Q. Is not anything which changes the composition of the atmosphere which we breathe, dangerous to health in a greater or less degree?

A. I should say the question was scarcely definite enough for me to answer yes or no.

569 Q. Is the healthiest atmosphere that which nature has made?

A. That is decidedly the dictate of experience.

Q. If any change of any kind is made in that, does it not in a greater or less degree make it unhealthy?

A. The atmosphere is variable somewhat.

Q. Can you answer my question or can you not?

570 A. It is simply a question as to the degree of change. There are many changes that could be made, which would not affect the health appreciably or at all. Most atmospheres might even be changed for the better, as regards health.

Q. Now, the Manhattan Company's process—what change would it require to introduce that at the Metropolitan works?

A. That is, also, a question which the engineers would have to answer. I could say, generally, that additional buildings would be required; and I presume an additional exhauster, or engine of some kind, for producing a current of air through the purifiers.

Q. What additional buildings?

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A. An additional building for the supplementary purifier at least.

Q. Anything else.

A. It would require an additional engine house and room for the exhauster. This additional building for purifying is nothing more than a brick building—perhaps twenty feet square. That is a very small matter. The engine and boiler would be the main thing—the engine for driving the air through.

Q. Is that a matter requiring great time?

A. I believe it generally takes some time to set the boilers and erect an engine and get them in working order. 572

Q. It is simply the time necessary to set a moderate sized engine?

A. I presume so, so far as I can say, not being an expert in that particular branch.

Q. You have spoken of over purification, and of the effect of absorption of naphthaline—what is the effect of it—anything but to reduce the illuminating power. Is it anything other than that?

A. I don't know that it produces any other injurious effects. 573

Q. I understand you to say that in your opinion, the New York Gas Company's process allows too much sulphur to pass into the rooms?

A. That would seem to be the conclusion, not only from general experience in the iron process, but also from Prof. Chandler's direct investigation.

Q. You state in your pamphlet that "the Metropolitan Gas Companies have consequently been unable to comply with the conditions required by the Metropolis Gas Act of 1860, that the gas shall not contain more than twenty grains of sulphur in one hundred cubic feet." Speaking of the London companies, you consider the parliamentary requirement, reducing the sulphur to 20 grains in 100 cubic feet, as reducing it to the point of health? 574

575 A. I consider gas containing 20 grains of sulphur as still decidedly objectionable, if better can be done.

Q. Then you consider that the parliamentary limit of 20 grains, to which the London companies have been enabled to reduce it, is still leaving it unhealthy?

A. Under circumstances favorable to the development of its detrimental effects, I should.

Q. Schultz is a competent chemist, is he not?

A. In gas matters he is a very good chemist.

Q. Then when he states that the New York Company's iron process has reduced it to 12.91 grains of sulphur in 100 cubic feet of gas, you admit that is about one-half less than the English parliamentary limit?

A. I should not attach much importance one way or another to those figures given there, as to the quantity of sulphur. They are both in my opinion lower than is probably the truth—considerably lower.

Q. Then why do you say in your pamphlet, "the most striking fact developed by the above short but significant report, is the high degree of freedom from sulphur of the gas of the Manhattan Company," if you did not believe it to be true?

A. I spoke there of the report.

Q. Why did you, in a report to the company, quote another report which you did not believe to be true, and state "that that was exceedingly significant and satisfactory?"

A. It would be rather strong language to say that I do not believe the report to be true. I believe it to have been low in all probability—the word believe is too strong a word to use in the connection, in my opinion.

Q. Do you believe that this report of Mr. Schultz is correct?

A. I think in the main it is.

Q. Do you believe it to be correct in its statement of the sulphur in the gas of the New York and Manhattan Companies?

A. I have no belief on the subject. I think it is not strictly correct.

Q. How long have you so thought?

579

A. One important piece of information which led to the modification of my opinion upon that subject, was Professor Chandler's investigation.

Q. How long have you so thought it was not correct?

A. Since I have myself been occupied with Professor Silliman, within two months past, in some determinations of the sulphur in gas, which have led me to believe that some determinations of the sulphur heretofore made, have been too low.

Q. Then I understand you that you consider this report of Mr. Schultz, so far as it relates to the amount of sulphur, as valueless?

580

A. The results of Mr. Schultz and Dr. Torry were doubtless obtained by the method which has been in ordinary use by gas companies for determining the sulphur, and which was introduced by Dr. Letheby. Several other chemists have recently come forward with the opinion, within the last year, that all the determinations made by Dr. Letheby's apparatus are too low, and that the amount of sulphur is much higher than has been placed by him, showing that the amount of sulphur as indicated by Letheby's method is incorrect.

581

Q. It is the method which has been used in England for determining whether the companies there have conformed to the parliamentary standard?

A. Yes, sir; and it is very seldom that it has given 20 grains, until quite recently.

Q. If by a process which is used abroad to determine whether the gas comes up to the parliamentary standard, it is found that the oxide of iron process gives eight grains less of sulphur than the parliamentary standard requires, does it not show that that process is superior to the process in use in London?

582

A. A great deal depends upon the coal that is used in making the gas. If very pure coal is used, free from sulphur, applying the same process of test abroad and here, we get eight grains less in the New York Company's process than is required by the parliamentary standard—between seven and eight grains.

583 Q. Taking that same test, does that not show, that the iron process in use by the New York Company is, so far as sulphur is concerned, superior to the process in use abroad?

A. It would simply show, to my mind, that it is probable that just at that particular time, the New York Gas Light Company were operating in some way; either by the aid of coal favorable to such a result, or by that, combined with other means, of scrubbing for instance, which they use, as I am told, so as to produce a gas very free from sulphur. I do not know that the oxide of iron
584 process—I do not know that it would be right to attribute the whole result to that.

Q. Here is a test that is used abroad, which gives between seven and eight grains of sulphur less to 100 cubic feet, than the parliamentary standard requires. Now, it being stated by yourself that the companies in London cannot even come down to the parliamentary standard, does not that fact show that the process of the New York Gas Company furnishes a gas purer and more free from sulphur than that of the London companies?

585 A. Speaking of the whole process of the New York Gas Light Company I should answer in the affirmative.

Q. I understand you to agree with Prof. Silliman in saying this; in so far as purposes of health are concerned, the question of naphthaline and phenol may be left out of this consideration?

A. I consider them very minor matters.

Q. Do they have any bearing whatever other than the fact that phenol is a disinfectant?

586 A. I should prefer to throw them out of this consideration. I think they bear about as much upon one side as the other, in every aspect, both *pro* and *con*.

Q. Is not sulphide of ammonium found in gas purified by the Manhattan process?

A. I have not recently tested the gas of the Manhattan Company. So far as my own knowledge extends, they do not deliver gas containing detectable sulphur.

Q. Was not the sulphide of ammonium found in the purified air, on being delivered from the supplementary purifier?

A. It was, but in a very minute quantity. It was scarcely perceptible to smell, though it was to lead paper. 587

Q. You have used in your direct testimony, at various times, the words, "There is no evidence, that so and so occurs in, or is accomplished by the iron process." What do you mean by that? Do you mean that you have not investigated it sufficiently to say that these things are accomplished, or what do you mean?

A. There is more than one case of the kind, to which different answers would apply. There are cases in which, if I remember aright, I made use of that remark, in which the matter has been investigated. 588

Q. The expression is peculiar, "There is no evidence."

A. I mean that we cannot proceed in chemical matters any more than in legal matters, without some evidence—without facts to start from.

Q. When you say that there is no evidence that such and such things are eliminated by the iron process, do you mean that does not eliminate, or simply that you do not know that it is eliminated? 589

A. I simply mean that no chemist has ever brought forward any evidence from experiments, that it has been eliminated.

Q. Do you mean that no chemist has ever brought forward any evidence that it has not been eliminated?

A. In some cases I do. In the case, for instance, of the bisulphide of carbon, some chemists have made very extensive experiments with bisulphide of carbon. They found compounds of bisulphide of carbon with lime, but they found none with oxide of iron that I could find any evidence of. 590

Q. Do you know whether they looked for any?

A. No, sir; I cannot say that.

Q. Did they say that they found none, or simply failed to mention them?

A. If they had found them they would have mentioned them.

591 Q. Do all gas companies apply the scrubbing process. Is it in use by all companies?

A. No, sir; not by all.

Q. Is it in use by all the companies in this city?

A. I think the Manhattan Gas Light Company do not scrub their gas before condensing it.

Q. In speaking of the hydrosulphuric acid and hydro-sulphate of ammonia in your pamphlet, you say, that "in the lime process the conditions present themselves merely for the arrest of all the free carbonic and hydro-sulphuric acids, and free ammonia salts, in definite forms of combination. In the case of the iron process this can by no means be asserted."

Q. Do you mean to say, by that, it is not true of the iron process?

A. No, sir; I mean that the weight of evidence is very much against it in the case of the iron process—the testimony of facts and investigations, so far as they have gone.

Q. In speaking under the head of carbolic and cresylic alcohols, at its close, you refer to the advantage of the lime, and then say, "which, however beneficial under peculiar circumstances, cannot be regarded as, by any means, indispensable and desirable as a compulsory infliction upon consumers of gas." What do you mean by "peculiar circumstances?"

A. I mean in case there are bad smells or an infectious atmosphere. Carbolic acid or phenol might then be even beneficial, but that under ordinary circumstances the delivery of gas containing creosote and like substances would be objected to in private houses. I should class phenol—however, I believe we have concluded that phenol is a matter of such importance, that it might as well be thrown out of consideration.

Q. On page 13, you make a quotation from the last edition of Clegg, and then one from Bowditch, and say that you are inclined to agree with Mr. Bowditch. I understand that to be your present view?

A. The first paragraph, although taken from the

edition of 1866, is very likely a copy taken from the 595
previous edition.

Q. Then, I understand the view you there express to
be the views you now entertain?

A. Do you refer to the passage commencing, "I am
constrained?"

Q. Yes, sir.

A. I still have that opinion.

Q. If you are of the opinion that there is still a worse
smell at the Metropolitan Company's works, when they
change their purifiers, than at the New York Company's 596
process, what opinion do you entertain then of the
Metropolitan Company's process?

A. I stated at the very outset of my examination, I
am confident, if my recollection serves me, that there
was a bad smell given out by the Metropolitan works.

Q. The point is here. You make a quotation, in
which you say, "The vapors of the hydrocarbons are
much heavier than the atmosphere, and when evolved
from the foul oxide of iron by the heat of chemical
action, they float in the lower stratum of the atmosphere, 597
near the surface of the earth, and produce extensive
nuisances. There are few smells more offensive to many
persons than the smell of these compounds given off by
the oxide in the process of revivification, and in every
gas works. They ought to be consumed instead of
being allowed to escape. If this be not done voluntarily,
the law ought to compel it." Then you say, "I am con-
strained to state that my own observation, so far as the
natural capacities of my mind and senses extend, bears 598
out the positive assertions of the Rev. Mr. Bowditch in
the latter paragraph." Having stated that, and having
stated further here, that the smell from the Metropolitan
Gas Company's works is more than that from the New
York, what, in your opinion, should be done with the
smells given off by the Metropolitan Company's works?
He said they ought to be burnt up in the other case?

A. They should most certainly be prevented by the
best means which offer to accomplish that result, be-

599 cause they are unpleasant to the public. I should state, however, I certainly ought to be allowed to recall, that when I stated there was a worse smell at the Metropolitan Company's, I spoke of the works, and not of the neighborhood at a greater or less distance from the works, because I should say precisely the opposite with regard to that. At a little distance from the New York works, I perceived a bad smell, and across the street from the [Metropolitan works I perceived a very slight smell.

600 Q. Do I understand you to say that the smell from the Metropolitan Company's works is not perceptible at a distance from the works?

A. I have not succeeded in perceiving it at a distance of about one block from the works—I mean the offensive stench. I have not happened, it may be a mere accident, to catch the very offensive stench which has been spoken of.

601 Q. You say on page 15, "as regards the peculiar unknown substance which diffuses itself from the purifiers when opened." To what purifiers do you refer?

A. I was then speaking generally of the ordinary dry lime process of purification, without any assistance from other devices.

Q. You are still of the opinion that that odor has a resemblance to, or belongs to the class of sickening odors, and is developed and intensified by aerial dilution?

A. I have perceived such odors.

602 Q. Are you still of the opinion expressed in that passage?

A. In connection with my last reply I am.

Q. How do you account for the fact that it is intensified by atmospheric or aerial dilution? How do you account for the fact that you smell it at the works and do not smell it across the street?

A. I did not smell it at the Metropolitan Gas Works,

as I have said in my direct evidence, I have tried to 603
catch some of it in a shawl and could not get any of it.

Q. You smelled some of that class of smells?

A. No, sir. The smell at the Metropolitan Gas Works
was a different smell from that referred to. I did not
perceive any of this smell at the Metropolitan Gas
Works at the time I visited it.

Q. Then you did not smell, at the Metropolitan Gas
Works, the peculiar unknown substance which diffuses
itself from the fouled purifiers when opened?

A. Certainly not so much as I have perceived for
example about a building, the roof of which was having
coal tar put upon it.

Q. Then if you did not perceive the peculiar odors 604
which came from fouled purifiers, to what odors did you
refer when speaking of the smell as being offensive?

A. In the Metropolitan Gas Works?

Q. Yes, sir.

A. I referred to the smell of sulphate of ammonia,
which was perceptible in the purifying house, and to a
certain distance around it.

Q. Did you perceive any other offensive smell than
that of sulphide of ammonium?

A. I perceived the smell of naphthaline, which is
rather pleasant to me.

Q. Did you perceive any offensive odor from the
purifier? 605

A. I have already stated that I perceive an odor
which was usually classed as offensive.

Q. But it was not the odor you referred to on page
15?

A. I did not recognize it as such. I attempted to
account for that in my direct evidence by attributing it
to the scrubbing of the gas—the copious quantity of cool
water which has taken off all these offensive materials,
in all probability, to the tar well.

Q. Have you ever heard of the oxide of iron process
catching fire?

606 A. It is spoken of frequently in books. I have not had it under my personal observation.

Q. Do the books say that it has caught fire, or that there was danger of it?

A. They say that it has caught fire, I believe.

Q. At this time that you went to the Metropolitan Gas Company and did not perceive these odors from the purifiers—was your arrival there expected, were you there by appointment?

607 A. On my first visit, when the purifier was opened, it was expected; but I am not aware whether it was or not on the visit which I made with Professor Silliman. I do not think it was expected, certainly the time was not set.

Q. What is your opinion as to the proper future of the Metropolitan Gas Company as to its process of manufacturing?

608 A. It was answered in great detail by me, to the best of my recollection, in my direct testimony. I gave my opinion as an expert that the Metropolitan Gas Company should be guided by the past experience of other companies—by the past history of the controversy, as it has taken place already.

Q. Is it not your opinion that they ought to put the process in use which is used at the Manhattan Company's works?

609 A. I do not feel as if it were a proper question to ask me on this occasion. I have no objection to reply to it if it is insisted upon. I do not look upon myself as called upon here as an expert to advise the engineers of the Metropolitan Company as to their duty.

Q. You are here as an expert. I will put it another way. Is it your opinion that, out of consideration to the public convenience—leaving health out of the way—a gas company having its works situated as the Metropolitan Company's are, should introduce the Manhattan Company's process?

A. So far as my knowledge of gas purification extends, I should think, if I am required to give an answer to that question, I should answer in the affirmative.

Q. Aside from all theoretical considerations, is it not 601
a fact that the gas companies in nearly all the large cities
in Europe have been compelled by the sanitary author-
ities to modify their process of so manufacturing as to
prevent the dissemination of the offensive gases which
are still liberated by the Metropolitan Company from
their fouled lime?

A. My general reading of gas literature permits me
to answer that in large cities and densely populated
neighborhoods, they have.

611

Q. In other words, your answer is in the affirmative?

A. It is in the affirmative, I believe, if I understand
the question distinctly.

Q. Is the *American Gas-Light Journal* a recognized
authority?

A. It is the only authority in the shape of a journal in
this country upon gas matters.

Q. In the number for February 16th, 1869, the article
under the heading of the "War of the Purifications,"
when did you first see that article?

612

A. Is it necessary to be very precise about the time?
I don't know that I can recollect aright.

Q. Give it as precisely as you can?

A. I think I saw it there on Wednesday or Thursday
last.

Q. After its publication?

A. That question I shall decline to answer; I do not
think I am called upon to give the authorship of an
article in a paper; it is attributed to the editor of the
paper.

613

Q. Did you write the article?

A. (By advice of Judge Van Vorst) I wrote the
article.

Q. Does it express your opinion?

A. Well, so far as any opinion is expressed in it, it
does.

Q. Does it state correctly your position?

A. Not my individual position; it states the position
of the Journal.

614 Q. But it does not state your individual position ?

A. I did not feel called upon then, nor do I feel called upon now, to state my individual position in the case.

Re-direct examination by Judge Van Vorst :

Q. Do I understand you to say, in answer to the question of Col. Bliss, that in your opinion the Metropolitan Gas Company would do well to adopt the process of ventilation in use by the Manhattan Company ?

615 A. It would, in my opinion, be well for them to thoroughly examine into the process used by the Manhattan Company, and adopt it in some form of modification. I do not look upon it as a perfect thing by any means as yet. No process is perfect ; they might be able to improve upon it.

Q. By Mr. Bliss : It is the most perfect you know of, is it not ?

A. It is, as I said in my examination.

Adjourned to Wednesday, February 24th, at 1 o'clock.

Saturday, February 27th, 1869.

Oscar Zollicoffer, called for the Metropolitan Gas-Light Company, being duly sworn, testifies as follows :

616 Examined by Judge Van Vorst :

Q. You are the President of the Metropolitan Gas-Light Company ?

A. Yes, sir.

Q. How long has that Company been in operation ?

A. Five and a half years.

Q. What district do you light ?

A. From 34th to 79th streets, between North and East rivers.

Q. You used the lime process for the purification of gas ?

A. Yes, sir ; at present dry lime.

Q. Was that process in use throughout the city when 617
your Company went into operation ?

A. There was none other than that ; it is only lately
that we knew of another process.

Q. What, if any, preparations or efforts have your
Company made to remove the effete lime after it has
purified the gas—state what you have recently done on
that subject ?

A. I have engaged boats, as I promised Dr. Chandler
six months ; when the material is placed on the boats
the hatches are closed without any delay and then it is 618
removed over to New Jersey, where we have engaged
dumping-grounds.

Q. That is to say, as soon as the purifiers are opened
the lime is removed to those boats lying at your docks ?

A. Yes, sir.

Q. And the hatches are closed on the lime immediately ?

A. Yes, sir.

Q. And that you mean to continue ?

A. Yes, sir, until another method is found out for
purification. 619

Q. Has your Company any preference for the dry
lime process of purification, if there is a better process
than that ?

A. Not in the least ; I told Dr. Chandler that very
thing ; we want the very best, whether it is lime or oxide
of iron ; we want that which is the best for the purifica-
tion of the gas, and at the same time which will retain
its illuminating power.

Q. The object of the Company is to obtain the best 620
gas, and also to have the best illuminating power ?

A. Yes, sir, we would like to improve upon any
method.

Q. Since this proceeding has been pending before the
Board of Health, what have you done about ascertain-
ing the process of purification in use in Europe ?

A. We sent out a special man that was recommended
to us very highly from two well-known chemists, to as-

621 certain the different modes of purification in use there ;
he has just returned.

Q. What did you send him to Europe for ?

A. To ascertain the modes in use in England, in
France, in Germany, to see what improvements could
be made, and with the intention to immediately adopt
that which from the different reports he should make
should be the best, after its being submitted to the Board
of Health, if acceptable to them ; I proposed to Dr. Chand-
ler, as soon as it is in operation, that he shall come and
see it on the premises ; if it had not been for the press
622 of business we could have had it in operation by the 1st
of March ; the spent lime is all going to be removed ;
it is now being removed, a large quantity being taken
each day ; there is no smell to that lime.

Q. You are having that removed all the time ?

A. Yes, sir ; we want the room ourselves.

Q. You say that your time is engrossed in extending
your works ?

A. Yes, sir, in extending our works and making im-
provements and repairs ; we occasionally need very much
623 this year.

Q. Has there been any special pressure on your com-
pany this year ?

A. Yes, sir, particularly so ; from the increase of the
consumption of gas in the district ; we must build more
retorts and gas-holders this year.

Q. Your works have been tested to their utmost
capacity ?

A. Yes, sir, to the utmost in December and January ;
624 to the utmost they could produce.

Q. What, if any, steps has the company taken lately
for the purpose of introducing any improved method for
the purification of your gas ?

A. As I said before, we engaged a chemist and sent
him to Europe.

Q. Has your Board appointed a committee to intro-
duce an improvement immediately ?

A. They have; they made me chairman, and appointed three members to take it particularly in charge. 625

Q. With instructions to introduce immediately some improved system of purification?

A. Yes, sir.

Q. So as to avoid all offensiveness?

A. Particularly to avoid all bad smell; I forgot to say we had a chemist who has been making experiments and has several times destroyed the bad smell in small quantities of the effete lime, and he believes he can do it on a large scale. 626

Q. That is, remove the foul odors from the spent lime?

A. Yes, sir.

Q. And you think those experiments you will be able to report on Monday?

A. We will begin to work by it on a large scale, we think Monday and every day next week; the lime will be put into the liquid to destroy this smell; it is an experiment only, and I can't say it is perfect only on a small scale; next week all the spent lime is to be treated according to this new process. 627

Q. Which is the result of some recent experiments of this chemist you have spoken of?

A. It is a wonderful success on a small scale; the sulphur is taken out and is crystallized.

Q. Is your company in good faith now engaged in the work of so purifying the gas as to get rid of all offensive odors?

A. Yes, sir.

Q. Col. Hastings is under the impression that you are pursuing the Fabian policy? 628

A. No, sir.

Q. Your Board has no preference for your present system of purification over any better system?

A. No, sir; on the contrary, I prefer the other one; I heard of it in Europe, and I told our engineers repeatedly that it was my view and I am certainly in favor of it.

Q. You would be glad if the process of purification

629 by oxide of iron should prove to be a good process, and if so, your company would have no objection to adopting it?

A. No, sir; they would not have any objection.

Q. What should you think of adding a little lime to the oxide of iron purification?

A. That is my impression; I am not competent to speak upon that subject, but I think it will be adopted again in English works.

Q. You think they will supplement the iron process
630 with the lime?

A. Yes, sir; with one larger.

Q. Would you think that would have any effect upon the candle power of the gas?

A. Chemist says so and our engineer; we have got a chemist who has discovered what I think will no doubt be an improvement; I can't give the name as it might interfere with our arrangements.

Q. Have you ever seen this process which is in use by the Manhattan Company?

631 A. Yes, sir; it is just the same as ours; I have seen the retort—exhausters—where it passes through; Dr. Chandler told me he was not satisfied with that, that it was only carrying it from one place to another.

Cross-examined by Col. Hastings:

Q. Is there any other company in the city that is using the dry lime process in the same manner as it is used by the Metropolitan Company?

632 A. I think the Manhattan has recently adopted theirs—the ventilation.

Q. Do you not regard the process as used by your Company as the most offensive of any now in use in this City.

A. Allow me to say, that I cannot say anything of that kind; the odors arising from our gas-works in our neighborhood are not offensive; we have four blocks round from which no complaints have come; Dr. Stone

told me that in two years only two complaints had been 633 made.

Q. During the process of the purification of the effete lime at the Metropolitan Works, is not a strong and pervading stench produced?

A. Immediately when you open the purifier, but not longer than for half an hour afterwards.

Q. Does not that stench extend a great distance from the works?

A. Not two blocks; we are different from the Manhattan Company, in that they do a large business, while we do a comparatively small business; I would like to 634 have gentlemen come and see our works.

Q. Do you mean to say that the odors from this effete lime do not extend beyond two blocks?

A. Except perhaps in very damp weather, for a day or two.

Q. How long have you known of the improvement now in use at the Manhattan Gas-Works?

A. I should think about eighteen months.

Q. Do you know any reason why your Company could not adopt a similar improvement?

A. Because we do not think it is sufficient. 635

Q. Do you know any reason why your Company could not adopt the same improvements?

A. I think it is not quite sufficient; I don't think it would be satisfactory to the Board of Health.

Q. Do you know any reason aside from that why your Company might not adopt it?

A. Except that we are very crowded for room. It is a sliding ground there, and it is very difficult to make a 636 high tower.

Q. Your company could obtain the room for that purpose?

A. Far off; not near by.

Q. Do you know any reason why your company could not adopt the method of purification in use at the New York works?

A. That is because it has not proved a success. Mr.

637 Adams, the President of the Company, told me about three or four months ago, when I was there in August. He said, "Mr. Zollicoffer, do not adopt it. Every day the gas changes; one day it is good and one day it is poor. The gas is not uniform." You can examine him and he will tell you the same.

Q. When was this committee for introducing a change appointed?

A. That was only at the last meeting—Wednesday of last week.

638 Q. Were they invested with full powers?

A. Yes, sir.

Q. With full powers to make the improvements?

A. Yes, sir.

Q. This is the first decided step taken by your company for the introduction of a change?

A. No, sir; we have given you already what has been passed by the Board.

Q. But no committee was appointed?

639 A. No, sir; it was left with the President and officers of the company at that time.

Q. And beyond sending an agent to Europe and the recent experiments you have spoken of, nothing has taken place with reference to a change since this investigation commenced?

A. Have been all the time reading and studying.

Q. No other experiments?

A. No; we hadn't the time to spare.

640 Q. When was this chemist employed to report on a better process?

A. It was in September or October, when he went to Europe.

Q. What is his name?

A. Schussler; he resides in this city.

Q. You say that the process recommended by him is to be introduced at the works?

A. No, sir; that is another one.

Q. When was the chemist employed who is about to recommend a new process to your company?

A. It is about three weeks ago first. 641

Q. Who is he ?

A. Mr. Milachon ; it is a French name.

Q. The experiments made by him are with direct reference to deodorizing the effete lime ?

A. Yes, sir.

Q. Is the process upon which he is experimenting to be introduced into your works ?

A. If it proves to be good it will be. I will not introduce anything permanently except I first consult with Dr. Chandler. 612

Q. Have any number of experiments been made upon that process in your works ?

A. Yes, sir ; several times last week.

Q. And those experiments are about to be extended ?

A. Yes, sir ; this week largely—on Monday, if all the boxes are ready. We have to get all the apparatus made.

Q. Have boxes been ordered sufficient for the entire amount of effete lime ?

A. What is made fresh. 643

Q. Fresh effete lime ?

A. Yes, sir.

By Judge Van Vorst :

Q. As the boxes are emptied ?

A. One is emptied at a time every second day.

By Col. Hastings :

Q. There is a considerable quantity of effete lime which has been removed from the Metropolitan purifiers now lying in an exposed state in this city ? 644

A. Yes, sir.

Q. There is over 100,000 bushels ?

A. I should say by this not much more, that is the spent, has no bad smell at all.

Q. During the process of removing the effete lime

645 from the Metropolitan purifiers, as now conducted, is it not exposed to the surrounding air?

A. Not more than five minutes—just the transportation to the boat.

Q. When did you adopt this improvement of shipping the lime?

A. About five days ago the boats came up.

Q. To what point was it removed?

A. Over to Bull's Ferry.

646 Judge Van Vorst put in evidence the resolutions passed at the meeting of the Board of Directors of the Metropolitan Gas Light Company, on the 24th of February, marked Exhibit D.

(Exhibit D.)

At a meeting of the Board of Directors of the Metropolitan Gas Light Company, held at the city of New York, on the 24th day of February, 1869, the following resolutions were passed:

647 *Resolved*, That it is, and always was, the sense of this Board, that the process of the manufacture and purification of gas in use by this company should be such as to avoid all just ground of complaint on the part of the Board of Health, or of any citizen of New York, referring to a memorial presented by this Board to the Board of Health, August 17th, 1868.

648 *Resolved*, That a committee of three members of this Board be appointed with authority and power to put in operation, as soon as can be done, a judicious system of purification, which shall be an improvement on the company's present method.

That in carrying out this resolution, such committee are empowered to adopt such improved system of purification as will prove satisfactory, and to apply the same at the company's works as soon as can be done.

Resolved, That in considering such improvement the committee be governed by the two principal objects, to

give the best and purest quality of gas to consumers, 649
and manufactured and purified in such manner under
the most recent and best methods, and so as to be at-
tended with the least possible offence or annoyance to
the public.

Resolved, That a copy of these resolutions be trans-
mitted to the Board of Health.

Resolved, That Thomas T. Buckley, David H. Mc-
Alpin, and Robert H. Arkenburgh, constitute such com-
mittee.

Attest.

650

WM. MEIKLEHAM,
Secretary.

By Judge Van Vorst :

Q. Would you suggest the oxide of iron process sup-
plementing that of lime ?

A. That is what I believed would be the result ; we
wish to give the best gas and manufacture with the least
offence to the public.

By Col. Hastings :

Q. How much time is required for the transfer of the 651
refuse lime from the purifying boxes of the Metropoli-
tan Works to the vessel ?

A. Five minutes.

Q. The entire contents ?

A. I should say two hours at the most—less than two
hours.

Jesse Lissenden, called by the Board of Health, being
duly sworn, testified as follows. Examined by Col. 652
Hastings :

Q. You are an engineer of the Manhattan Gas Com-
pany, of this city, are you not ?

A. At that company ; not of the company.

Q. Of the works ?

A. Yes, sir.

Q. How long have you been employed in that capa-
city ?

653 A. Nearly fifteen years.

Q. And during this time you have been familiar with the method of purifying gas in use at the Manhattan Gas Works?

A. Yes, sir.

Q. What is the process used by the company you represent?

A. I suppose it is called the dry-lime process.

Q. In what respect does it differ from the process employed at the Metropolitan Works?

A. I don't know that it differs at all.

Q. Is the method of ventilating the refuse lime different from that in use at the Metropolitan Works?

654 A. I don't know anything about the Metropolitan Works.

Q. What is your method of ventilating the effete lime?

A. By oxidizing the foul gas that remains in the lime after the purification.

Q. State how this is done.

A. The cover is first raised from the box and shifted one side.

Q. From the purifying box?

A. Yes, sir; then the exhauster is applied underneath the bottom of the box for two hours; the exhauster runs, I think, about 800 revolutions a minute.

655 Q. Runs by steam?

A. Runs by steam, yes, sir; after that, the men go to work and take out the first tier of plates, which makes an opening right to the bottom of the box on each side, that allows the air to go down underneath, giving free vent right through; after it has worked in that way for one hour it is closed off; we then run the exhauster another hour with an opening in the engine room sufficient to let the fresh air go through the engine room, through the deodorizer, and out of the chimney where all the foul gas escapes; that is supposed to put out all that is not taken out by the deodorizer.

Q. The gas that remains?

A. Yes; sir; after three purifiers have been applied, 656
the material in the deodorizer is changed. We never
put more than three through it without supplying it
with fresh material.

Q. After the effete lime has been through the process
you have described is it inodorous?

A. I can't say.

Q. What is your opinion? Is it offensive to smell?

A. I should think not; no, sir. I could not say posi-
tively, for I have never taken particular pains to smell
of it. Of course it can't be expected that it will be made
as pure as pure air by any process that can be devised.

Q. Why was this change you have spoken of intro-
duced?

A. Because there were so many complaints around. 657

Q. Do you find in practice the improvements you
have described successful?

A. I believe it gives general satisfaction.

Q. Does it meet the end for which it was designed?

A. I think it does.

Q. Since its adoption have there been any complaints
in regard to the offensiveness of the refuse lime at your
works?

A. Well, sir, I have heard some of the bosses com-
plain of it in the works. The men sometimes say that
something is not working right.

By Judge Van Vorst:

Q. Complain of a bad smell? 658

A. They say so.

By Col. Hastings:

Q. Have there been any complaints from the neigh-
borhood in regard to the offensiveness of the foul lime
since the adoption of this improvement?

A. I don't know that there have; not that I re-
member.

Q. The only complaints that have reached your know-
ledge are from the employees in the works?

A. Yes, sir. There are various causes, you know, for
their finding fault with the smell since the adoption of

659 this new improvement; for instance, if the exhauster, instead of running 800 revolutions, is run no more than 400 or 500, you could not expect it to produce the same result as when it runs 800; but if the belt slips we have to stop and take it up. Probably we may run on one purifier only before we detect that the belt has slipped and that the exhauster is not making the revolutions that it should do. Then, of course, there would not be the amount of suction on that purifier, and the smell would probably be a little bad.

660 Q. During the process of deodorization, as conducted at your works, can offensive gases or odors be detected outside the works?

A. Yes, sir, but very seldom; as this gentleman before me stated, in foggy weather you may find a little smell.

Q. In works now using the dry lime process, what changes would be necessary to introduce the improvement used by the Manhattan Company?

A. I don't know. State that again.

661 Q. In works now using the dry lime process, as ordinarily conducted, what changes would be necessary to introduce the improvement used by the Manhattan Company?

A. They would need to have a suction pipe attached to every box in the house—the bottom of it—and then they would need to have an exhauster, as we have, and then they want another box in a small building by itself, and a chimney connecting with this box.

662 Q. Do these changes involve any interruption in the manufacture of gas?

A. They need not do so.

Q. Is any additional room required for the use of this improvement?

A. Oh yes.

Q. How much?

A. The exhauster would take five or six feet square.

Q. Is that all the additional room required?

A. That is all that part would require.

Q. Then there is the steam engine. What further 663
room would that require?

A. It requires ground enough to build the house for a
deodorizer and chimney.

Q. About how much?

A. I suppose that building, as near as I can guess, is
20 feet square, or probably more; it might be 25; I
could not say positively. Then the chimney, which is
60 feet high, that would require some space.

Q. Do you regard the introduction of this improve-
ment by any company using the dry lime process, as 664
entirely practicable?

A. Yes, sir, if they have got the space to put the ma-
chinery, and the chimney, and the house on. I forgot
to tell you that there is another article attached to that
deodorizer, a water concern. That is a new thing which
has been put in there within, I can't tell you positively
how long a time, but I should think inside of fifteen
months.

Q. Scrubber?

A. A kind of washer, something of that kind. I have 665
not seen it. I have been told it was there.

Cross-examined by Judge Van Vorst:

Q. About how long would it take to make all these
erections. You speak of the chimney; putting up the
engine. About how long?

A. You have become too tight upon me.

Q. How long would it take your company to do it?

A. I could not say.

Q. Could you say about how long?

A. No, sir, I could not come within three or four 666
months of it. I would not like to say anything about it.

Q. Do you think engines could be ordered and all
those buildings be put up within three or four months?

A. Provided they had men enough.

Q. It could be done?

A. It could be done in four months, I think.

Q. All these improvements could be made?

A. Everything.

- 667 A. I want to ask you this question--whether there is any part of your improvement in use by the Manhattan Company, for ventilating the effete lime or the deodorization of it, which is subject to a patent? A. Yes, sir.
- Q. Who owns the patent?
- A. The architect of our works. His name is Farmer.
- Q. You say that there is some unpleasant smell about the works?
- A. Occasionally.
- 668 Q. Do you know of any method of the manufacture or ventilation of gas, except there would be some smell about it?
- A. I do not.
- Q. The object of your company has been so to purify it as to have the least possible smell?
- A. Yes, sir.
- Q. When this system of ventilation you spoke about is in use, there is on some occasions an unpleasant smell?
- A. Yes, sir.
- 669 Q. Especially, as I understand you to say, when the air is moist and heavy it drives the odors which come out of that chimney down to the earth?
- A. I suppose so.
- Q. And at times the bosses about your establishment have complained of smells--about smells?
- A. Yes, sir.
- Q. By Col. Hastings: You say Mr. Farmer has a patent?
- A. Mr. Farmer has a patent on the exhauster.
- 670 Q. The method of purification is the same in use as at the Metropolitan Company, except in the matter of ventilation?
- A. I suppose so; I have not been there.
- Q. The only difference is the supplementary process of ventilating of the effete lime?
- A. Yes, sir.
- Q. Your company has not the exclusive right to use any portion of the machinery you describe?
- A. Not that I know of.
- Q. By Judge Van Vorst: Do you think they have not

A. I know there has been one manufactured and put 671
up outside of our works in the city. I think it was for a
different purpose—for blowing fires.

Q. The question which Col. Hastings asked you, and
which I should like to have you answer was this:
Whether the patent is owned by the Manhattan Com-
pany?

A. It is owned by this man Farmer. The company
have nothing to do with it that I know of.

Q. Do you know what other companies in this city
use the dry lime process, except the Metropolitan and 672
the Manhattan? How does the Harlem purify?

A. I don't know.

Q. By Col Hastings: Are you familiar with the oxide
of iron process?

A. I am not.

Q. So far as you know, your company is perfectly
willing that other companies should adopt the improved
system of ventilating lime?

A. So far as I know.

Peter Cartwright, called by the Board of Health, be- 673
ing duly sworn, testifies as follows:

Examined by Col. Hastings:

Q. Are you in the employ of the New York Gas
Company?

A. I am.

Q. In what capacity?

A. As a practical engineer.

Q. How long have you been so employed.

A. For twenty years.

Q. What process of purifying of gas is in use by that
company? 674

A. The iron process.

Q. State in what form the iron is used in that process?

A. The iron ore we get from Staten Island, and with
it is placed a percentage of iron borings and turnings,
and we mix the mass with ammoniacal liquor to oxidize
and prepare it for use.

675 Q. How long has this process been used in your company ?

A. Ten months.

Q. What process was in use by your company previous to this process ?

A. Dry lime.

Q. What changes were necessary in the introduction of the present process ?

A. Well, very little changes indeed—introducing a new bottom with skids of wood.

676 Q. New bottoms to the purifying boxes ?

A. Yes, sir, that is a superficial bottom to receive the iron oxide.

Q. How much time would be required to make this change in any gas works using the dry lime process ?

A. About five hours in the putting in the new bottom and be ready to turn on again when the lime was fouled—this is the way we turned on ours.

677 Q. If a gas company using the dry lime process had a double set of purifiers would this change to the iron process involve any interruption in the manufacture of gas ?

A. Not at all ; with only one set it would not.

Q. How does the iron process, as used by your company compare with the dry lime process in respect to offensiveness.

A. Our house is now like a bed of roses to what it was when we used lime.

Q. Your company found the dry lime very offensive ?

A. Yes, sir ; very indeed.

678 Q. And was it that cause that led them to the adoption of the iron process ?

A. It was ; and to comply with the law.

Q. Is the iron process used by your company practically inoffensive ?

A. There is no offensiveness whatever about it.

Q. Does the gas manufactured by your company differ in illuminating power in the use of this method ?

A. I don't know, to my knowledge ; some say it does, 679
and some say it does not.

Q. Do you know how your company regard the iron
process ; whether as a success, or a failure ?

A. They consider it a success.

Q. Do you know whether they have any intention of
modifying or changing the process they now use ?

A. I do not.

Q. How does the process used by your company
compare with the dry lime process in respect to expen- 680
siveness ?

A. There is a great economy in the iron process ; I
think it will save our company this year \$113,000
in iron alone—material alone ; the labor is not so
much because of the offensiveness of the lime ; in winter,
when we were making our greatest consumption, we
had to employ a double set of men sometimes, and men
would be knocked over, and then we would have to em-
ploy men in their places, and pay them too ; I have
picked them up and carried them out myself. 681

Q. When you were using the dry lime process ?

A. Yes, sir.

Q. Knocked down by what ?

A. The offensive smell.

Q. How many instances of this character do you rec-
ollect ?

A. I could not tell how many, there has been
so many ; I have picked them up myself and carried
them out ; one day the lime man was bringing in a
load of lime, and the man was going over when our 682
men caught him, or else he would have gone over and
the horse and cart would have gone on to him ; the
horse fell down, and we had to take him out of the har-
ness, and take him out in a lot.

Q. Men and horses were affected in the way you de-
scribe when the lime was being removed from the puri-
fying boxes ?

Q. We had broken into them then for ventilation, and
the fumes starting out of the house met them ; we had to

683 let them stand for four or five hours before we could get the lime out.

Q. Is any additional room required for the use of the iron process ?

A. No ; we made no additional room ; it would be better with additional room, certainly, or else in a shed or out-building.

Q. Can the oxide of iron be revived in the open air, or do you require a building for that purpose ?

684 A. It can be revived in the open air, but it is better if you protect it in storms ; of course it is better if protected from the weather.

Q. Is any odor given off from this iron mixture during the process of revivification ?

A. Not at all.

Cross-examined by Judge Van Vorst :

Q. How long has this process of purification by you company been used ?

A. For ten months.

685 Q. Before that you used dry lime ?

A. We did.

Q. How long have you been an engineer there ?

A. Twenty years.

Q. And were you an engineer during the time they used the dry lime ?

A. I was.

Q. Is any part of the process of this purification by the oxide of lime patented ; have you a patent for it ?

A. We have.

686 Q. From whom did you get the patent ?

A. From the parties at Washington.

Q. Who owns the patent ?

A. Me, for one.

Q. Do your company ?

A. Me, for one.

Q. Are you interested in the patent ?

A. I am.

Q. And you think well of that process ?

A. Yes, sir.

- Q. There is no smell of gas from the fouled iron ? 687
- A. There is not.
- Q. Is it pleasant, on the other hand ?
- A. Yes, sir ; I think so.
- Q. Does it deliver as pure gas as the gas purified by the lime process ?
- A. I don't know of my own knowledge.
- Q. Does it take out the carbonic acid ?
- A. In a great measure it does ; in a small measure it might not. 688
- Q. Does the presence of carbonic acid increase or diminish the candle power ?
- A. I should think it diminishes it a little.
- Q. Then the gas delivered purified by the oxide of iron has not so great an illuminating power as that which is purified by the lime process ?
- A. I think it would if the iron and the lime process was carried the same distance ; I think the iron process would retain its luminosity for a greater distance than the lime process. 689
- Q. Do you mean to say that ?
- A. I do.
- Q. I ask you this question : Does the iron process take out all the carbonic acid ?
- A. No, sir.
- Q. Therefore, it does not purify quite so well as the lime in that respect ?
- A. No.
- Q. In respect to taking out carbonic acid, the iron process does not take it out as well as the dry lime ? 690
- A. It does not.
- Q. In order to get this right to purify with the oxide of iron we must get the right from you, must we not ?
- A. For what ?
- Q. We must obtain the right to use it from your patent ?
- A. Certainly.
- Q. From you ?
- A. Certainly.

691 Q. You say you never heard any complaint made about bad smell since the oxide of iron was used there, from anybody?

A. From anybody.

Q. Have you heard no complaint about the gas delivered?

A. I have seen it in the *Press*.

Q. What have you seen in the *Press* about it?

A. Why, saying that the gas burned blue, &c.

Q. That the gas burned blue, &c.?

692 A. Yes, sir; I did not see that, but I saw the words of Prof. Wurtz here, who made use of those words. I did not see it in the *Press* myself before that.

Q. Haven't you heard complaints made of that gas, that its candle power was diminished?

A. I have.

Q. You have heard those complaints?

A. I have.

Q. That the candle power of the gas purified by the oxide of iron was diminished?

693 A. I have heard so.

Q. Repeatedly?

A. Yes, sir.

Q. From consumers?

A. Never. Not a word from consumers.

Q. From whom?

A. From opponents of the oxide of iron process.

Q. From those who were opposed to the purification by the oxide of iron process you have heard that the candle power was diminished?

694 A. Yes, sir.

Q. Don't you think it is diminished a little?

A. I do not.

Q. Don't you think the candle power is diminished some?

A. I do not.

Q. Not at all?

A. I do not.

Q. Not in the least degree?

- A. I do not, to my knowledge. 695
- Q. After the iron is taken out of the purifiers, what do you do with the foul oxide of iron?
- A. Throw it out on the floor.
- Q. For what purpose?
- A. To oxidize it.
- Q. Is there nothing given out; are there no emanations proceeding from it?
- A. No smell.
- Q. Are there no emanations proceeding from it?
- A. Yes, sir. 696
- Q. There must be some emanations?
- A. Yes sir: there is a vapor rises from it when in a state of oxidation.
- Q. There must be room of course to have this iron, after you have taken it out of the purifiers, to ventilate it?
- A. Certainly, must have room, of course.
- Q. Do you know how the Harlem Company purifies its gas?
- A. I do not, from my own knowledge; I heard that they purified with lime; that is all I know about it. 697
- Q. Dry lime?
- A. I have heard so.
- Q. Have they got any ventilator?
- A. I don't know.
- Q. Are you taking measures to introduce your patent throughout the country—this process of purifying gas by iron?
- A. Will serve anybody who will take it.
- Q. Are you or are you not taking measures to introduce it? 698
- A. We are not.
- Q. You are doing nothing about it?
- A. We never applied to anybody, or to Mr. Zoll-coffer, nor any other parties around New York.
- Q. Have you advertised it?
- A. We have.
- Q. You are doing it now?
- A. We are not.

- 699 Q. You have advertised it lately, have you not ?
 A. I should think not for five or six months.
 Q. You have advertised the sale of the right to use it ?
 A. Certainly.
 Q. And you are doing it now ?
 A. Yes, sir.
 Q. To any person who wishes to buy it ?
 A. Yes, sir.

Re-direct examination by Col. Hastings :

- 700 Q. How came you to make the invention spoken of ?
 A. We tried to comply with the law and to destroy the offensive odors around the works.
 Q. You are making experiments to that end ?
 A. Yes, sir.
 Q. Relating to the removal of the offensiveness by the old process ?
 Q. Yes, sir.
 Q. Under what auspices were you making such experiments ; under whose directions or request were you making these experiments ?
 701 A. The request of the President of the Company.
 Q. Of the New York Company ?
 A. Yes, sir, Mr. Adam.
 Q. Were these experiments satisfactory to the Company ?
 A. They were glad to get hold of it.
 Q. And for that reason the process was introduced in the New York Works ?
 702 A. Yes, sir.
 Q. By whose advice, if any, did you obtain a patent upon the process ?
 A. No one's advice ; only we advised each other ; two of us were associated, William H. St. John and Peter Cartwright.
 Q. You obtained a patent, I suppose, because you regarded it as a valuable improvement and a success ?
 A. Yes, sir.

Q. Has the New York Company any interest in the patent? 703

A. Not a cent.

Elisha Harris, M. D., being called for the Board of Health, being duly sworn, testifies as follows. Examined by Col. Hastings.

Q. State, if you please, your profession and residence?

A. I am a physician and reside in West 42d street.

Q. How long have you been in that profession?

A. For the last 20 years, sir.

Q. And in what professional relation are you at present employed? 704

A. A Sanitary Superintendent of the Metropolitan District.

Q. Have you read most of the testimony adduced in the hearing under the order relating to the Metropolitan Gas Company?

A. I have read about two-thirds of all the testimony that was given prior to you sitting to-day, from the first.

Q. In addition to the examination of the evidence referred to, have you given the subject of the best method of purifying gas any study or attention? 705

A. Only so far as connected with the questions of sanitary improvement in cities, where these questions have been already examined, and in connection with the progress of chemical knowledge, as these questions illustrated some of the leading facts in the chemistry of gases.

Q. Do you know what gases, if any, are given out from the foul lime removed from the purifying boxes of any company using the dry lime process? 706

A. The gases which are given out in such a manner as to be the object of special examination and remark by sanitary officers and physicians, are mainly the sulphuretted gases and undefined and unestimated amounts of the compounds of cyanogen, but chiefly the sulphuretted gases, the sulphide of ammonium being evolved

707 after a time when the fouled lime is exposed to the atmosphere.

Q. Are any of the gases escaping from such fouled lime recognized by sanitarians as injurious to life or detrimental to health?

A. Yes, sir; all the compounds or complex sulphur gases, except sulphurous acid in vapor, which is not to be mentioned as a gas, are recognized as directly injurious to health, the sulphide of ammonium being the most poisonous of the sulphur gases which are known to sanitary science; the experiments with these different gases being too incomplete to enable us to compare them relatively, we can speak of the sulphuretted hydrogen and the sulphide of ammonium as being chiefly the obnoxious gases evolved from the foul lime when exposed to the atmosphere.

Q. What evidence is there that sulphuretted hydrogen gas is dangerous to health?

A. First the large number of accidents from respiring the gas have abundantly proved that it is fatal to life when it exists in a certain percentage in the common atmosphere, or in the atmosphere of any room or place; then a great variety of experiments with small animals which have been very decisive in their character; and thirdly, observations upon persons who are compelled, from their vocations or by any accident, to breathe sulphuretted hydrogen for any considerable period day after day in their vocation; all these go to prove the same thing, that the sulphuretted hydrogen is injurious to health, and the experiments prove that a small percentage will destroy life; a percentage, however, of one per cent. does not necessarily destroy life, but whenever the percentage has been increased from point to point in the scale, the various animals that have been subjected to it have been killed. The list of experiments given in this volume which I have in my hand——

Q. What volume is that?

A. This is Hammond's Hygeine.

Q. Is it a standard work?

A. Yes, sir; this is a brief list; and, if you desire, a more complete list of experiments could be presented immediately, but this briefly shows how the case stands. I will read from page 156: "Sulphuretted hydrogen is exceedingly poisonous. Depuy *pere* found that 1-800 of this gas was sufficient to render the atmosphere so poisonous that small birds were killed in a few seconds when subjected to its influence. One part in 299 parts of atmospheric air proved fatal to a dog. Chausier found that one part in 250 of air was sufficient to kill a horse."

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Hammond further says: "The results of my own experiments with sulphuretted hydrogen do not differ materially from those other observers. I found with Dupuyten that all small animals, as birds and mice were killed by a smaller proportion of gas in the atmosphere in which they were confined, than larger animals. Sparrows and mice did very well in an atmosphere, 1-1000 of which was sulphuretted hydrogen. With more than this death ensued, though not until 20 or 30 minutes had elapsed." These were carefully made by Dr. H., who is a distinguished physiological experimenter. He continues: "On post-mortem examination the blood was found perfectly dissolved, and the blood corpuscles completely broken down. The action of sulphuretted hydrogen, when not inhaled in a large quantity, appears to be that of a narcotic poison. Its effects upon the organism when its action is long continued in a small amount, has not been so thoroughly investigated as desirable. That it is capable of producing injurious results is very certain. * * * * *

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Dr. Taylor, the author of a work on Medical Jurisprudence, refers to instances which occurred as to the poisoning by this gas of workmen engaged in excavating the Thames Tunnel, by respiring the atmosphere of this place. The strongest fellows were in a few minutes rendered extremely weak and several died."

All the evidence regarding the operation of the poison upon the blood, being so very important, that sanitary

715 officers have felt it necessary to ask for special experiments. A series of experiments on a large plan have been in progress for two years under the Health department of the Privy Council of Great Britain upon this and various allied subjects, some of the results of these experiments have also been published, much more conclusive than these older and more general experiments.

Q. Well, do the conclusions established by those experiments all tend to the same end?

716 A. They all show that these sulphuretted gases destroyed the blood corpuscles, which have always been recognized as constituting the most essential element in the whole range of the physiological constitution of the living body. To know just what kind of changes occur in the blood, while circulating under and exposed to the influence of these gases, has been one of the nicest and most exact kinds of chemical inquiry that have ever been pursued.

Q. What other gases escaping from fouled gas lime would you consider obnoxious to health?

717 A. The sulphide of ammonium is the asphyxiating gas of all others which is recognized as being the most quickly destructive to life, and it is combined in the gases which float off from the fouled lime, so that no ordinary observation, I suppose, could state which was in excess, but the special odor of sulphide of ammonia is far the most offensive. That is the gas that usually so quickly destroys life in persons who chance to go down into deep privy vaults, as scavengers, and that class of persons who have suddenly died on going into privy vaults—accidents that have actually occurred in this city, and which are recurring all over the world amongst scavengers.

718 Q. As a sanitarian, will you state what is your opinion as to the danger to the public health from the presence of the fouled gas lime within the limits of the city of New York?

A. If gas lime is exposed to the atmosphere it will

give off these deadly gases, and the sulphide of ammonia with certainty coming, that is derived from the sulphide of calcium, which exists always in abundance in the fouled lime, and it will float in the common atmosphere until such transformations have occurred as destroy its character, as sulphide of ammonia will float in the direction in which the wind is blowing, which is a fact well certified to by experiments, and in particular states of the atmosphere as regards temperature and barometrical pressure, it may float far over the city—so far as to become dangerous to health to a great distance. Again, the gas itself is judged to be more obnoxious at the distance of a few blocks from the mass of lime from which it is evolved, than it is immediately on the premises. My own observation fully confirms that as regards the effort to discover the localities within which this gas can be recognized by its odor and effect upon the respiration. I have smelled it as far eastward as the top of Murray Hill on Madison Square, and as far southward as 14th street, and frequently in West 42d street, where I reside.

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Q. Have you ever been able to trace these odors to their source?

A. Yes, sir; I was able to trace these odors without being at the time able to gain access to the fouled pile of lime, some years ago when the dry method was used in the works on the east side of the city. I do not think that to be a demonstration which would answer any positive purpose of a public statement, but to me it was entirely conclusive. Following merely the odor, and noticing the direction of the wind at the time.

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Q. To what distance did you then follow the odor?

A. I then resided one door north of the Rev. Dr. Bellows's church.

Q. On what street?

A. Between 20th and 21st streets. I should think it must be a mile to the gas works, perhaps three-quarters

723 of a mile to the nearest gas works, and I then made observations which satisfied me that the 14th street works gave off the nuisance quite as abundantly as those that were near to my residence, and more recently and last summer, when peculiar circumstances rendered it easy to follow any particular odor, from changes that had occurred in the atmosphere, making it peculiarly pure, and reducing the temperature by the change of the direction of the winds on the 5th day of July—I deemed it a duty to follow this kind of evidence up to its source, and asked one of the Sanitary Commission to join me, and in that case I was able to follow the odor directly to its source in the Metropolitan Gas Works.

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Q. From what point to what point?

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A. I observed the odor first at about 30th street, while walking up Broadway. On reaching my house in West 34th street, between 5th and 6th avenues, the odor was so oppressive in 34th street that I endeavored to follow from that point, and following from 34th street, I went with the Sanitary Commissioner, who joined me for the purpose, to the lime heaps which were then freshly covered with the foul lime that had been thrown out. This observation was made for the purpose of satisfying our judgment on the precise source of a particular odor and to see it with our eyes. There was then no intention of making it the ground of special complaint, because other companies in the city were known to be using the dry lime process of purification, but here was an opportunity to settle unequivocally a fact which was important to know.

726

Q. You found the source at that time to be the heaps of fouled lime of the Metropolitan Gas Works?

A. Yes, sir, unequivocally.

Cross-examined by Judge Van Vorst:

Q. Have you given the subject of the purification of gas practically any attention?

A. I have given it only that kind of attention practi-

cally which a person interested in sanitary knowledge must give if he would understand the source of impurity in the atmosphere, and the merits of questions which have become important in all great cities where gas manufactories are located in the midst of the population ; these questions are important in all the great cities of the world at present. 727

Q. You have given some attention to the subject of the merits of the respective method of purification in use, theoretically, have you not?

A. Yes, sir. 728

Q. Now, Doctor, as the result of your own investigation, which is the better purifier of the gas—which eliminates from the gas the most foulness ; the oxide of iron or the dry lime method of purification ?

A. Neither process perfectly purifies the gas from what you technically denominate impurities.

Q. I ask you which of those two processes is the better purifier ; I am not asking you whether any process does perfectly, but which of those two processes is the better purifier ? 729

A. I will answer your question directly and categorically as you put it, if you allow me to refer to substances instead of processes ; for as regards these two elements—natural elements—they are things and not processes ; if taken alone, either process would be objectionable, but if I am to answer that question as relates to these things I would say positively that lime will remove the largest amount of certain impurities, and hold those impurities ready to yield up again in another poisonous form, and iron will remove positively the same impurities, but not all of the same—the worst of the same—and will fix those impurities and not yield them up in a poisonous form ; so that regarding them as processes, there is first that difference to be stated and that fact to be stated ; then we have to commence anew with the fact how to proceed to finish the task of purification. 730

Q. Could you suggest any improvement upon the process or method or thing or whatever you call it in use at the New York Company for the purification of its gas ?

731 A. I have not seen the New York process; I know those only by name.

Q. The oxide of iron process, which is the only process in this city covered by a patent; could you suggest any improvements in addition to the use of the oxide of iron as it is used there?

732 A. I have not seen that, though I have been invited; I have been unable to give any attention to either process, and in my judgment, the oxide of iron process as used there has gradually diminished the offensiveness which people usually complain of in the neighborhood of gas works, but I don't know the extent of the completeness in the purification of the gas itself.

Q. But the gas itself, as delivered to its consumers, is not as thoroughly purified of sulphurous compounds as that which would be delivered by the lime process, do you think so, speaking chemically and theoretically?

733 A. There must be used, in addition to the iron process, however, that is used, some alkaline earth, or substance, or fluid that will receive and recombine certain impurities which the iron does not fully control.

Q. How would you suggest a little of the hydrate of lime as a supplement to it?

A. That is found by experience, to finish the job well.

Q. If the hydrate of lime in a moist form is used and not over-used, the quality of the gas that is burned is of the very highest that is known among gas manufacturers?

734 A. Such is the testimony of hygienists who have examined it, and no offensiveness is caused among the community in which the gas is made; but the hydrate of lime must be used after the iron process or you will have the offensiveness, because the iron is used merely to fix certain things which are very difficult to control, viz., these sulphur compounds which go to form the sulphide of calcium, &c., in the lime process, but then here is the carbonic acid gas which must be controlled in order to give the quality that is needed to the gas; there is a re-

siduum of sulphur which needs to be withdrawn if possible; the experiment of withdrawing it by secondary purification, I believe, has resulted triumphantly in several instances. 735

Q. In order to put this thing in a practical form, oxide of iron does not thoroughly remove the carbonic acid, and there is still in the gas a residuum of sulphur, so I understand you to say?

A. Certainly, sir.

Q. And which, if it was subject to a supplementary or subsequent process of purification by the hydrate of lime, you think it would remove that carbonic acid and the residuum of sulphur the iron had failed to take out? 736

A. The supplementary process with lime properly presented to the gas for this second purification, is said to be entirely triumphant, and the gentlemen who have certified it have undertaken the inquiry so intelligently and so conscientiously for the hygienic purposes, that I would like to present it as an item of evidence. 737

Q. I would like to ask this question, whether there is any danger, by subjecting the gas to this subsequent action of the hydrate of lime, after the iron has acted upon it, of enfeebling the illuminating power of the gas?

A. Of course there would be, unless the chemist was master of the situation and knew his trade.

Q. What effect does the presence of carbonic acid in the gas, which the oxide of iron fails to eliminate, have upon the illuminating power of the gas when combustion takes place generally? 738

A. I must say that practically I could not answer that question, and I merely state it upon the authority of chemists; it is not necessary that I should commit to paper any of the evidence, as it would not be original; it is but a small item, and imperfect as my own chemical knowledge might be, I would undertake to get out the carbonic acid gas without damaging the gas.

Q. Don't chemical writers say that the presence of carbonic acid in the gas, when combustion takes place,

739 diminishes its candle-power ; don't writers upon chemistry say that ?

A. They do, and display weakness on the spot when they say it, unless they show how that carbonic acid gas can be withdrawn.

Q. You have suggested a way to get rid of that by the use of hydrate of lime supplementary ; I call your attention to a process where the hydrate of lime is not used at all subsequently ?

A. I have answered the question.

740 Q. By Col. Hastings : Do you know of any authority recognized as such among sanitarians that discusses the question of these poisonous gases escaping from fouled gas lime upon the blood or health ?

A. I do.

Q. What ?

A. As I stated in the opening evidence upon the medical question, the blood does suffer directly when exposed to these gases ; I wish now to state that sanitarians have undertaken to find how it suffers, and whether
 741 such poisons can be resisted, because it is essential when studying the causes of diseases to find out what are inevitable poisons acting on the blood, and it turns out rather unexpectedly to some medical inquirers, that there are gases which are in a very absolute sense poisonous ; the carbonic acid gas has long since been found to be only contingently poisonous ; it destroys life ; but it was not the poison which could always be asserted as the source of particular conditions of ill health which were discovered in foul places ; what were the other gases
 742 was the question, and what kind of gases ; and in this inquiry which is now in progress, and probably will be for several years by the Medical Department of the Privy Council of Great Britain, which is the last report of the second installment of the chemical evidence on this very subject of the effect of certain exhalations, vapors and gases upon the blood, on the subject of physiological and pathological questions connected with these chemical and natural forces—this item of evidence oc-

curs bearing directly upon the question you ask; the 743
essential elements of the blood corpuscles, which is most
prominent and unyielding to all other effects which
disease produces is the Hematocrystalline that enters
into the constitution of every blood globule, and consti-
tutes a large percentage of it; in that Hematocrystal-
line is combined all the iron that floats in the blood; the
Hematocrystalline has become the subject of most care-
ful study, with reference to the changes therein gases pro-
duce; now it is found that carbonic acid gas does not
at once destroy Hematocrystalline; it is found that most 744
of the poisons that are introduced into the body will
break up the blood globules and still leave the Hemato-
crystalline to crystallize as Hematoidine; we have had
occasion to study the Hematoidine in the investigation
of last summer, and the history of its persistent life as
an element in the fluids, even of sick animals, is an in-
teresting fact; but certain gases act upon that Hemato-
crystalline and eliminate it so that it cannot be con-
structed into any of the forms of life in the animal
tissues; that destruction of a very persistent and im- 745
portant element therefore of the body comes to be a
specially important fact in hygiene, for we have been
hunting for years for methods of exact demonstration of
hygienic questions, and now it is done at the expense of
the Lords of the Privy Council in this class of studies
on a large scale. I will read from the Tenth Report of
the Medical Officer of the Privy Council, London, 1858,
at page 170: "A diminution of Hematocrystalline in the
body constitutes the disease termed chlorosis or anæmia; 746
it is either a specific element or a symptom and conse-
quence of chronic disorders, or particularly tropical
fevers." * * * "The Hematocrystalline is
the last ingredient of the blood which undergoes putre-
faction; its stability is the main factor in the stability of
life; this quality is perhaps mainly the result of the
power which it possesses of taking up oxygen from the
air, and yielding it again to other matter in contact.
* * * "Hematocrystalline combines readily

747 and more pertinaciously than with oxygen, with a number of these gases, such as carbonic oxide, sulphuretted and phosphuretted hydrogen. * * * The Hematocrystalline is the last ingredient of the blood which undergoes putrefaction ; it preserves its color and spectrum for years, in a horribly offensive mixture."

Q. That kind of evidence has this value in answering this question which has just been asked—that it is reducing to demonstration what hitherto had been stated in the way of assertion ?

748 A. It is showing how a change occurs, and in order to show how the highest resources of chemistry are brought into play, namely, spectrum analysis, and show the beginning, and progress and ending, of certain changes which occur when the blood is exposed to certain poisonous gases ; and the result of this inquiry shows that certain gases and these complex sulphuretted gases and the phosphuretted gases, and a large number of others, and compounds of cyanogen gas come into the same list, instead of merely dissolving and breaking up the blood globules, actually destroyed the chemical constituent, which in most diseases fails to get destroyed, so that the sanitary fact begins to be settled as a demonstration that certain gases should not be permitted to be evolved in a great quantity into the atmosphere which people breathe. Not that the people will be immediately killed, but that their health will be silently and persistently injured from a cause which no science before had perfectly controlled. Now, chemistry comes in with its exact methods of demonstration, but not until these higher applications of it by the beautiful method of the spectrum analysis had enabled us to get down to the 1000th part of a grain, and study it with the interest with which we could formerly study larger quantities.

749 Q. By Judge Van Vorst : The effect, I suppose, would be the same if these poisonous gases were evolved in the dwelling houses where combustion of the gas takes place ?

A. Oh, yes ; it makes no difference where the gases

come from if they are only there when people are res- 750
piring.

Q. If those foul, poisonous gases are not eliminated in the act of purification, they do appear in the dwellings when the combustion of the gas takes place?

A. No, sir; they do not in any perceptible quantity, for even sulphur appears as sulphurous acid.

Q. Isn't that poisonous?

A. Sulphurous acid is a poison only contingently. It does not even destroy the blood corpuscles, as it is presented to us in our respiration. It partakes of none of 751
the qualities which I have described concerning the truly poisonous gases.

Q. Does it depreciate property?

A. I have no doubt of that, because it will tarnish silver. That is not a sanitary question, however, it does not concern hygienists.

Q. Which do you suppose to be the worse, free sulphuretted hydrogen, or sulphide of ammonium free?

A. Sulphide of ammonium, far worse.

Q. Have you ever heard of any person being killed 752
by sulphide of ammonium?

A. I have known of cases, and they are very numerous; they are known in common life as suffocation and asphyxia.

Q. Occurring under what circumstances?

A. Occurring generally in old privies and similar situations; but there are cases which can be referred to as having occurred in a specific manner in gas-works; I need not adduce cases, because they are abundantly 753
verified.

Q. Can there be any sulphuretted hydrogen at all given off by the waste lime, if the prominent odor on opening the purifiers is that of ammonia?

A. Yes, sir; I have been present when gas purifiers were opened, and the predominating odor is sulphurous, and the ammonia is dissipated as the men are taking away the lime; and the lime which I have myself handled twelve hours after it had been thrown out, has

754 grown hot on exposure to the ordinary current of air. One week ago to day I made the experiment, and the sulphide of ammonium was eliminated in a very offensive and considerable volume, and I was told that the lime had laid nearly twelve hours, where it was in a mass; but there was no odor of ammonia there then, but had I been present at the opening there would have been an odor of ammonia perceived. 2/

Q. And the odor would have predominated ?

A. I suppose it would, so far as my senses were concerned ; it is one of the most pungent of gases to the senses ; it naturally would be predominant.

755 Q. Notwithstanding all that, and conceding that the predominating odor is that of ammonia, you do think that there might be sulphuretted hydrogen given off by the waste lime ?

A. I think so ; but I have not made exact tests of that question ; I believe it is a fact conceded that it is given off.

(No further testimony offered.)

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